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Acceptance of Beef Finished on Forages or with Limited Grain

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Preface

Questions concerning both consumer acceptance of beef produced on forages and the feasibility of producing slaughter beef on forages have been around for a long time. Since more forage than grain is produced in the South, beef producers in this region have been particularly concerned with such questions as: How much longer does it take to finish a steer on pasture than in feedlot? Can Choice grade beef be produced on forages? Is confinement feeding superior to feeding grain on pasture? Other questions arise at the retail level: Is there a market for beef from animals fed primarily on forages? Who are the consumers? What price will such beef command? What are the characteristics of the market?

The research reported in this publication was undertaken in an attempt to provide answers to some of these questions. A total of 197 animals were produced and slaughtered during this 3-year study (1975-77) to evaluate consumer acceptance of beef finished on forage or with limited amounts of grain. Feeding treatments tested included (1) forage, (2) grain on forage, and (3) feedlot feeding periods of 63, 70, 78, 108, and 140 days. Methods used in evaluating beef produced in these treatments included (1) retail sales, in which steaks and roasts were purchased at retail outlets and evaluated by 1,563 consumers; (2) a ''household'' consumer panel consisting of 609 households to which steaks were provided free for evaluation; (3) trained laboratory taste panels, and (4) laboratory tests including measurements with the Warner-Bratzler Shear.

Results obtained in this study provide a basis for optimism concerning the potential for producing slaughter beef primarily on forages. The findings indicate that the potential market for such beef is more real and extensive than had been realized, and that producers, wholesalers, and retailers may need to look more closely at this market for beef finished on forage or with limited grain.

It should be noted that high-quality beef cattle and high-quality forages were utilized in this study, which resulted in favorable findings for forage-fed beef. It is not likely that the findings would have been as favorable if cattle and pastures of lower quality had been used.

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Acceptance of Beef Finished on Forages Or with Limited Grain

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Introduction

Since the 1950's, there has been a steady increase in beef consumption in the United States, and particularly in consumption of Choice grade, grain-fed beef. One reason for this has been an abundance of reasonably priced beef, due to abundant supplies of relatively inexpensive feed grains.

However, future beef production may have to depend less on feed grains than it does today. Worldwide increases in petroleum prices have increased energy costs, which have increased costs associated with beef production and marketing, especially feed grain production, transportation, and distribution costs. Demand for grain for human consumption and livestock production in other countries has increased U.S. grain exports, causing feed grain prices to increase for domestic livestock producers. In addition, there has been a humanitarian call for the U.S. to provide grain for hungry people in developing areas of the world. At the same time, the average U.S. consumer has become somewhat wary of consuming animal fat because of a popular theory of a relationship between consumption of animal fat and health, especially heart disease. All of these factors raise questions concerning the future for extensive feeding of high-energy concentrates to beef cattle.

For the immediate future, however, it appears that relative amounts of grain and forage fed to beef cattle will fluctuate with world demand and supply of feed grains. While creation of international grain reserves can ease the influence of small year-to-year fluctuations in production and consumption, an expanding world population and growing appetites for animal protein will exert increasing pressures on world supplies of feed grains. In the long run, it is likely that U. S. beef cattle production will depend more heavily on forages.

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Problem

Industry conditions in 1974 justified a re-evaluation of production alternatives in the Southeastern States for cow-calf producers traditionally selling weanling calves as feeders, and for feedlot operators finishing calves on high-energy grain rations. Of particular interest was the alternative of finishing steers and heifers for slaughter on forages alone or with limited amounts of grain. Potential consumer acceptance of beef from animals finished in this manner was relatively unknown, particularly with regard to beef animals finished on high-quality winter pastures. Previous experiment station research throughout the Southeast has reported favorable live animal performance and carcass characteristics from these grazing programs. In November 1974, the Louisiana Agricultural Experiment Station initiated research to *determine the marketability and consumer acceptability of forage-finished and limited-grain-finished beef.* A three-phase cooperative project was developed involving the Department of Agricultural Economics and Agribusiness, the Department of Animal Science, the School of Home Economics, the West Louisiana Experiment Station, and the Department of Experimental Statistics.

Previous Research

Interest in finishing cattle for slaughter other than in feedlots was practically nonexistent during the 1950's and 1960's. Therefore, research results on cattle finished on forages were lacking. Feed grains were plentiful and the market for Choice, grain-fed beef was expanding rapidly. Gains could be achieved in the feedlot at costs equal to or lower than those involved in any other means of finishing. This cost-of-gain advantage permitted feedlot operators to purchase calves and yearlings at higher prices than could meat packers. Beef consumers appeared destined to enjoy Choice, grain-finished beef in increasing amounts at budget prices.

Two factors disturbed this situation in the early 1970's: higher costs for feed grain, and increased energy costs. These higher costs caused a change in the production of beef. Meat retailers, feedlot operators, and cow-calf producers were forced to modify their operations and seek alternative sources of supply and markets. Retailers began to market beef from short-term, grain-finished calves along with more expensive Choice grade, grain-finished beef. Feedlot operators reduced placements of calves in their lots and concentrated on purchasing heavier feeders that required less grain to finish to market weight and grade. Cow-calf producers, faced with a greatly reduced demand for lightweight feeders, sought new methods of handling and marketing these calves.

In response to this changing situation, several agricultural experiment stations initiated studies related to production of beef with less grain. In various studies, emphasis was placed on use of silage feeding programs, on reducing the percentage of concentrates in feedlot rations, on shorter periods of grain feeding, or on some combination of these things.

Some research may have been stimulated by a workshop on forage-fed beef held October 20-22, 1975, in New Orleans, La. This workshop was sponsored by the Southern Regional Association of Agricultural Experiment Station Directors, the Agricultural Research Service and the Economic Research Service of the U.S. Department of Agriculture, and the Tennessee Valley Authority. Papers on production and marketing alternatives in the South for beef finished with rations containing higher than typical amounts of forage were presented at the meeting and later published *(12)*.[6]

In general, researchers have reported consistent findings with respect to live animal performance and carcass characteristics from forage-finishing and short-term grain-finishing programs. Findings concerning consumer acceptance as determined by sensory panels, consumer panels, and laboratory evaluations have differed, however. Publications on Phases I and II of the LSU Beef Marketing Study reviewed recently completed research on consumer acceptance of forage-finished beef in some detail *(9, 10)*. Many researchers have reported similar consumer acceptance for beef finished on forage or with limited grain *(3, 4, 5, 14, 15)*. Other researchers have reported finding laboratory and/or consumer panel data showing a preference for beef finished with limited grain over forage-finished beef *(1, 2, 6, 11)*.

Overview

This report presents results from Phase III of the LSU Beef Marketing Study and summarizes the findings of Phases I and II. In each phase, Angus or Hereford x Angus cattle were produced and finished for slaughter at the West Louisiana Experiment Station, Rosepine. Live animal performance data were recorded for each phase. The cattle were slaughtered at a federally inspected plant on a custom basis and carcass measurements were taken, including grades, color readings, and shrinkage. Beef from all animals in each of the three phases was evaluated by a household consumer panel, a trained laboratory taste panel, and laboratory tests including use of the Warner-Bratzler Shear. Steaks and roasts obtained from the animals in Phases I and II were marketed in three Baton Rouge stores of a cooperating food retailer and were evaluated on a voluntary basis by some of the purchasers. Economic feasibility of the feeding treatments used in the three phases was estimated through use of experiment station records, graded carcass prices in the *National Provisioner* "Yellow Sheet" *(7)*, and/or composite retail prices obtained from sale of LSU beef in the supermarkets.

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[6] Italic numbers in parentheses refer to Literature Cited, page 41..

Prior to each phase, all test animals had been on comparable forage-feeding programs. Although the animals in each phase were of approximately equal age and weight when randomly assigned to final finishing programs, age and/or weight often differed when the animals were actually placed on final treatment. Test animals were continued on forage treatments until the designated date to begin the assigned final feeding treatment.

Numbers and sex of animals, feeding treatments, and length of feeding treatments differed somewhat among phases. Four or five feeding treatments were included in each phase (Table 1). Phase I included 10 steers in each of five feeding treatments: (1) forage only; (2) supplemental grain on forage; (3) 63 days feedlot; (4) 78 days feedlot, and (5) 108 days feedlot. Phase II included both steers and heifers. Sixteen steers were assigned to each of four feeding treatments in Phase II: (1) forage only; (2) supplemental grain on forage; (3) 70 days feedlot, and (4) 140 days feedlot. Nine heifers were also assigned to each of treatments 1-3 in Phase II. Phase III included 14 steers in each of four feeding treatments: (1) forage only; (2) supplemental grain on forage; (3) 70 days feedlot, and (4) 60 days supplemental grain on forage followed by 70 days feedlot. In total, 170 steers and 27 heifers were involved in the three phases. *Three feeding treatments were common to each phase: forage only, supplemental grain on forage,* and *approximately 70 days feedlot.*[7] Data from all treatments involving steers will be presented in this report. However, *only the three common feeding treatments will be discussed. This report will not present or discuss data from the evaluation of the 27 heifers in Phase II.*[8]

Animal and Carcass Data

Procedures

Types of pastures used were common and Coastal bermudagrass in summer and rye, ryegrass, and Louisiana S-1 white clover during winter and spring. Fertilizer (6-24-24) was applied to pastures at the rate of 200 pounds per acre in October and May. Ammonium nitrate was applied at the rate of 200 pounds per acre in October and May and 100 pounds in mid-February. Forage-finished steers and steers awaiting assignment to grain treatments were fed cottonseed meal and hay on pasture after August until winter pasture became available or until assigned to grain treatments.

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[7] The 70 days feedlot grouping includes a 78 days feedlot treatment in Phase I, a 70 days feedlot treatment in Phase II, and a 70 days feedlot treatment in Phase III.

[8] Heifer data are not presented in this report because heifers were included in only one phase; therefore, no comparisons among phases are possible as were done in this report for the steer data. DAE Research Report No. 509 *(10)* includes research results from the finishing and evaluation of the 27 heifers in Phase II.

Feedlot rations in Phases I and II consisted of ground yellow corn, cottonseed meal, and other supplements (Appendix Table 1). Rations were fed free-choice in a self-feeder. In Phase III, a ration of whole corn with supplement was fed free-choice in the feedlot. The ration given on pastures was hand fed daily in all phases and consisted of ground corn and urea.

Steers in Phases I and II were placed on final feeding treatments at prearranged dates so that the desired average treatment weight, which differed among treatments, would be obtained at the same time for all treatments. Steers in Phase I came off the final feeding treatment in February 1975 (Table 1). Phase II steers were removed from treatments in October 1975. Phase I steers averaged 23 months of age and Phase II steers averaged 20 months at slaughter.

In Phase III, all steers were placed on the final feeding treatment at approximately the same date. However, in Phase III the steers were

Table 1.—Feeding treatment, number of steers per treatment, date of slaughter, and age at slaughter, LSU Beef Marketing Study, Phases I - III

Phase	Feeding treatment	Steers per treatment	Heifers per treatment	Date of slaughter	Age at slaughter (months)
I	Forage	10	0	Feb 1975	23
	Grain on forage[1]	10	0	Feb 1975	23
	63 days feedlot	10	0	Feb 1975	23
	78 days feedlot	10	0	Feb 1975	23
	108 days feedlot	10	0	Feb 1975	23
	Subtotal	50	0		
II	Forage	16	9	Oct 1975	20
	Grain on forage[2]	16	9	Oct 1975	20
	70 days feedlot	16	9	Oct 1975	20
	140 days feedlot	16	0	Oct 1975	20
	Subtotal	64	27		
III	Forage	14	0	Apr 1977	29
	Grain on forage[2]	14	0	Oct 1976	24
	70 days feedlot	14	0	Nov 1976	25
	60-70[3]	14	0	Oct 1976	24
	Subtotal	56	0		
	Total	170	27		

[1] While slaughtered in February directly off forage, the steers had received ½% of body weight of grain per day for 188 days during the previous summer and fall.

[2] 1% of body weight of grain per day on forage.

[3] 60 days of 1% grain on forage followed by 70 days feedlot.

removed at a uniform average weight of 1,050 pounds from October 1976 to April 1977. The latter procedure resulted in less differences among feeding treatments, but time on test ranged from 287 to 465 days. Phase III steers also differed in age when removed from test, ranging from 24 to 29 months.

All steers were slaughtered at the same federally inspected meat packing plant. In Phases I and II, steers from each treatment were slaughtered over a 4-week period to permit marketing of much of the carcass as fresh retail cuts through a cooperating retail food chain. In each phase, standard carcass information was obtained after a 72-hour chill and portions of the blade chuck, short loin, and top round were transported to LSU for subsequent testing.

Warner-Bratzler Shear, color, and pH values were determined on the *longissimus* (loin) muscle from the 11th and 12th rib samples of all carcasses.

Live Animal Performance

Grazing and grain-feeding data by treatment and phase are shown in Table 2. Gains by steers in Phase I were greater than anticipated. Some of the gains could have been due to compensatory gain, since the steers had been fed cottonseed meal and hay before being placed on ryegrass and they were grazed for only a short time (70 days). However, daily gains for the forage-finished steers in Phases II and III were low. In Phase II, the steers were grazed for 160 days on summer pastures after being on ryegrass. Switching from a higher quality to a lower quality forage had a depressing effect on gains. These cattle were slaughtered in October after the bermudagrass pasture had declined in quality. In Phase III, forage gains were less than expected because a dry fall and colder than normal winter resulted in a short ryegrass season for 1976-77.

Even though the grain-on-forage treatments are grouped together, the treatment was somewhat different in each phase. During Phase I the steers were not fed grain while grazing ryegrass; however, these steers had received a daily ration of grain equal to one-half percent of their body weight for 188 days during the previous summer and fall (a total of 751 pounds of grain per head). Phase II steers were fed daily 1 percent of body weight of grain for 120 days while grazing bermudagrass pastures. Phase III steers received the same percentage of grain for 284 days, so they consumed more than twice as much grain as did the Phase II steers (2,200 pounds per steer). Daily gains for the steers from the three phases were similar (approximately 1.75 pounds) even though the grain-on-forage treatment was not the same for each phase.

The feedlot treatment of approximately 70 days was about the same for all three phases, except: (1) Phase I steers were fed for 78 days; (2) placement weights of the steers differed among phases, and (3) Phase III

Table 2.—Steer performance data by feeding treatment, LSU Beef Marketing Study, Phases I - III

Treatment and phase	No. of steers	Initial weight[1] (lbs.)	Beginning weight on treatment[2] (lbs.)	Final weight (lbs.)	Daily gain, total[1] (lbs./day)	Daily gain, treatment[2] (lbs./day)	Days on experiment[1]	Days on final treatment[2]	Grain consumed (lbs./head)
Forage									
I	10	827	827	1,014	2.69	2.69	70	70	—
II	16	657	657	837	1.07	1.07	160	160	—
III	14	503	503	1,052	1.18	1.18	465	465	—
Grain on forage									
I	10	927	927	1,040	1.63	1.63	70	70	751[4]
II	16	667	716	929	1.63	1.78	160	120	943
III	14	496	518	1,049	1.85	1.86	300	284	2,201
Feedlot									
I									
63 days	10	795	795	1,047	4.03	4.03	63	63	1,602
78 days	10	808	808	1,099	3.75	3.75	78	78	1,978
108 days	10	810	810	1,085	2.56	2.56	108	108	2,844
II									
70 days	16	656	772	962	1.91	2.71	160	70	1,866
140 days	16	658	692	1,049	2.44	2.56	160	140	3,377
III									
70 days	14	491	870	1,056	1.76	2.65	323	70	1,392
60-70[3]	14	495	742	1,047	1.93	2.35	287	130	1,725

[1] Based on the total time the animals were assigned to the project.
[2] Based on the amount of time the steers were assigned to the final feeding treatment.
[3] 60 days of 1% grain on forage followed by 70 days feedlot.
[4] These steers had received ½% of body weight of grain per day for 188 days during the previous summer and fall.

steers received a whole-corn-with-supplement ration while a ground-corn ration was fed in Phases I and II. Steers in Phase I were placed on feed at 808 pounds, Phase II steers at 772 pounds, and Phase III steers at 870 pounds. Average daily gains for feedlot periods alone were 3.75, 2.71, and 2.65 pounds per day for Phases I through III, respectively (Table 2). Phase I steers experienced compensatory gain, which explains their average daily gain of 3.75 pounds. However, steers in Phases II and III gained more than 2.6 pounds per day. Feed efficiencies (pounds of feed per pound of gain) for the 70-day feedlot periods were 6.8, 9.8, and 7.5 for Phases I through III, respectively. Phase II steers had the poorest feed efficiency of the three groups, perhaps because they were in feedlot during hot weather.

While steers in Phases I and II were removed from treatment at the same time, there were big differences in final weights, especially in Phase II. Forage-finished steers in Phase II weighed 108 pounds less than the average of groups given grain in that phase. In Phase III, each treatment group was removed when the steers averaged 1,050 pounds. As expected, forage steers required the most time to reach final weight. The forage steers took an additional 160 days to reach 1,050 pounds, as compared with the average of the grain-fed groups. Steers receiving grain at a daily rate of 1 percent of body weight for 60 days, followed by 70 days in feedlot, reached final weight first, consuming 476 pounds less feed per head than steers receiving 1 percent grain for 284 days. The 70-day feedlot steers required the least amount of grain, but took about a month longer on test than did steers receiving 60 days of 1 percent grain on forage followed by 70 days in feedlot.

Shrinkage and Dressing Percentage

Normal marketing procedure used in each phase was to weigh the cattle off test on a Thursday morning, transport them from the station to the slaughter plant (a distance of 190 miles) during the day, provide access to water overnight, and weigh them the next morning before slaughter. Average treatment weights at the station and at the slaughter plant are shown in Table 3. Weight loss during hauling and holding at the packing plant is commonly termed shrinkage and is expressed as a percentage of original weight. Average shrinkage was 7.5 percent. In Phases II and III, forage-finished steers lost the greatest percentage of liveweight and cattle fed grain for longer periods lost the least. However, in Phase I, shrinkage was as great for grain-finished steers as for those finished on forages or with grain on forages.

Dressing percentages were low for all steers, whether finished on grain or not. As expected, underfinished forage steers in Phase II had the lowest dressing percentage. The remainder of the steers had similar dressing percentages.

Table 3.—Steer weights and carcass data by feeding treatment, LSU Beef Marketing Study, Phases I - III

Treatment and phase	Station weight (lbs.)	Slaughter weight (lbs.)	Weight loss[1] (%)	Hot carcass weight (lbs.)	Hot dressing percentage[2]	Fat thickness (in.)	Ribeye area (sq. in.)	Ribeye area/ 100 lbs.[3]	Yield grade	Quality grade[4]
Forage										
I	1,014	930	8.3	550	54.2	.23	11.2	2.04	2.3	9.9
II	837	769	8.1	423	50.5	.13	9.8	2.31	1.9	8.6
III	1,052	966	8.1	578	54.9	.33	9.8	1.70	2.8	9.6
Grain on forage										
I	1,040	954	8.3	583	56.1	.26	11.0	1.89	2.4	10.2
II	929	865	6.9	502	54.0	.29	10.4	2.07	2.4	9.3
III	1,049	976	7.0	587	56.0	.49	10.6	1.81	3.2	11.4
Feedlot										
I										
63 days	1,047	956	8.7	577	55.1	.29	11.4	1.97	2.3	10.4
78 days	1,099	1,004	8.6	610	55.5	.33	11.7	1.92	2.5	10.8
108 days	1,085	998	8.0	605	55.8	.32	12.0	1.98	2.4	10.7
II										
70 days	962	892	7.3	532	55.3	.39	10.6	1.99	2.7	10.8
140 days	1,049	975	7.1	596	56.8	.51	11.2	1.88	3.1	11.3
III										
70 days	1,056	1,008	4.5	584	55.3	.41	10.6	1.82	3.0	11.7
60-70[5]	1,047	975	6.9	568	54.3	.47	10.3	1.81	3.2	12.2

[1] Station weight minus slaughter weight, divided by station weight.

[2] Hot carcass weight divided by station weight.

[3] Ribeye area expressed in square inches per 100 pounds of hot carcass.

[4] 9=Low Good, 10=Average Good, 11=High Good, 12=Low Choice.

[5] 60 days of 1% grain on forage followed by 70 days feedlot.

Carcass Characteristics

Selected carcass characteristics for the treatments in the three phases are shown in Table 3. Average fat thickness varied from .13 to .49 inch, with none of the treatment groups being excessively fat. Steers fed for 70 days produced carcasses with uniform, very desirable fat thickness, with average external fat ranging from .33 to .41 inch.

Average ribeye size ranged from 9.8 to 11.7 square inches. All treatment groups except forage steers in Phase III had average or above average ribeye areas on the basis of square inches of ribeye per 100 pounds of hot carcass weight.

All groups had desirable cutability; yield grades varied from 1.9 to 3.2. As expected, forage-finished steers had the lowest yield grades (best cutability). Yield grades increased (cutability decreased) as the amount of grain consumed increased. Steers finished with 70 days in feedlot had very uniform cutability, with yield grades of 2.5, 2.7, and 3.0 for Phases I through III, respectively.

Average carcass quality grades for each treatment group are listed in Table 3. The forage treatment had the lowest quality grades, and quality grades improved as additional grain was consumed. Even in Phase III, when all steers were slaughtered at similar weights, forage-finished steers had lower quality grades than steers in the grain treatments. However, they also had less fat than the grain-finished steers.

The distribution of quality grades for each treatment is shown in Table 4. It was difficult to produce Choice grade beef on forages. Only five of the 40 forage-finished steers (12.5 percent) graded Choice. Similar percentages of steers graded Good from the forage and grain-on-forage treatments (42.5 percent *vs.* 47.5 percent). However, grain-on-forage treatments produced 20 percent more Choice and 25 percent less Standard carcasses than the forage treatments. The 70-day feedlot treatments produced the largest percentage of Choice carcasses (57.5 percent), but still had 17.5 percent Standard carcasses. However, six of the Standard carcasses were obtained in Phase II when the average final station weight was 962 pounds. Grades of steers in Phase III that were grazed with supplemental grain and then finished in feedlot were similar to those of the 70-day feedlot group for that phase.

Marbling trends were the same as those for quality grades (Table 5). Forage-finished steers produced the least marbling, 70-day feedlot steers produced the most, and grain-on-forage steers were intermediate.

Laboratory Analyses

Warner-Bratzler Shear values indicated feeding treatment had no influence on tenderness of the *longissimus* (loin) muscle. Results were consistent for all three phases. Even trimmer Phase II forage-finished steers were

Table 4.—Quality grade distribution by feeding treatment, LSU Beef Marketing Study, Phases I - III

Treatment and phase	Grades[1] Low Prime	High Choice	Avg. Choice	Low Choice	High Good	Avg. Good	Low Good	High Standard	Avg. Standard
Forage									
I				3	2	1		3	1
II				1		3	2	6	4
III				1	4	2	3	2	2
Grain on forage									
I				3	1	2	2	2	
II			1	2		2	5	5	1
III			3	4	4	1	2		
Feedlot									
I									
63 days			1	2	1	2	4		
78 days			1	3	3		3		
108 days				1	7		2		
II									
70 days			5	4		1		5	1
140 days		2	2	5	2		5		
III									
70 days		1	5	4		2	1	1	
60-70[2]	2	1	6	1		1	2	1	

[1]Number of carcasses in each 1/3 of quality grade.
[2]60 days of 1% grain on forage followed by 70 days feedlot.

not significantly tougher, which indicated the carcasses had not undergone cold shortening.[9]

Both forage and grain-on-forage steers had external fat that was more yellow in color than that of the 70-day feedlot steers (Table 5). The additional grain consumed by grain-on-forage steers had no influence on fat color. The forage steers also had a darker colored lean, as measured by visual color score or by the Hunter color difference meter. However, the darker color was not due to a higher pH except in Phase II. There were a few carcasses in the Phase II forage-finished group that could be termed "dark cutters." This may have resulted in the higher pH for this group as compared with other treatments. The pH values were not higher for the forage-finished steers in either Phases I or III, although they had darker lean. Some of the color differences may have been due to less marbling in the forage-finished steers. The grain-on-forage treatments produced muscle color scores similar to those produced by the 70-day feedlot treatments, as determined by the Hunter color difference meter. Steers finished with 60 days grain on forage followed by 70 days in feedlot

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[9] Carcasses with less insulation (less fat) undergo a more rapid chill, causing muscles to contract more during rigor mortis, which results in tougher lean tissue.

Table 5.—Muscle quality components by feeding treatment, LSU Beef Marketing Study, Phases I - III

Treatment and phase	Degree of marbling[1]	Warner-Bratzler Shear[2]	Color of fat[3]	Color of lean[4]	Hunter color score[5]	Muscle pH
Forage						
I	5.8	19.4	3.7	3.4	45.8	5.56
II	4.3	21.4	1.8	3.3	45.1	5.84
III	8.3	18.8	2.8	3.0	41.1	5.51
Grain on forage						
I	6.3	19.9	3.2	3.0	45.7	5.53
II	5.4	22.7	2.4	2.4	42.2	5.64
III	10.0	19.3	2.7	2.6	39.4	5.49
Feedlot						
I						
63 days	7.3	20.2	1.5	2.7	45.0	5.50
78 days	7.3	19.4	1.1	2.5	44.7	5.50
108 days	7.5	18.8	1.3	2.7	44.5	5.51
II						
70 days	7.6	22.5	1.7	2.4	42.3	5.64
140 days	9.0	23.0	1.4	2.1	40.6	5.64
III						
70 days	11.0	18.5	2.3	1.9	39.3	5.49
60-70[6]	11.2	19.4	2.6	1.9	39.3	5.51

[1] 21-point scale, 4-6 = trace, 7-9 = slight, 10-12 = small.
[2] Pounds required to shear a 1-inch core of cooked muscle tissue.
[3] 1-6 scale, 1 = white, 2 = tinge of yellow, 3 = slightly yellow.
[4] 1-7 scale, 2 = cherry red, 3 = slightly dark red.
[5] Hunter color difference score, $\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$.
[6] 60 days of 1% grain on forage followed by 70 days feedlot.

(Phase III) had about the same values for muscle quality components as the 70-day feedlot steers.

Retail Sales

Procedures

The marketplace provides the supreme test of consumer acceptability of any product. Initial and repeat sales are the key to success in the retail market. While sales of a given product under test conditions do not guarantee that a viable market exists for that product, they may suggest that a market exists or could be developed.

Steaks and roasts from steers in Phases I and II were test marketed in supermarkets alongside USDA Choice beef. A major food chain agreed to market the LSU beef in three Baton Rouge stores. Store personnel cut the beef into retail cuts and packaged the cuts in their normal manner. Each package was clearly labeled as containing beef produced by LSU and was

SPECIAL BEEF SALE

Winn-Dixie Stores, Inc. is cooperating with a Louisiana State University Beef Marketing Project in offering beef fed on natural forage and grains, by the Louisiana Agricultural Experiment Station. This beef was slaughtered in a *Federally Inspected* plant and packaged by *Winn-Dixie Stores, Inc.* *Much of the beef is lower in U.S.D.A. grade and in price than the stores' normal marketings. All purchasers are requested to complete and return the meat evaluation forms enclosed in the meat packages.*

Your cooperation will help the Louisiana Agricultural Experiment Station assist the Louisiana Beef Industry to produce the kind of beef you want to purchase and consume.

LSU beef on sale in retail food store, Baton Rouge, 1975.

placed in a separate section of the fresh meat case beside USDA Choice beef.

The LSU beef was marketed on Thursdays, Fridays, and Saturdays for a 4-week period in each of the two phases. Purchasers did not know which feeding treatment produced particular cuts. However, they did know the beef was from forage-finished and limited-grain-finished cattle.

The LSU beef differed from the store's regular beef offerings in both weight and grade. Therefore, price adjustments for the LSU beef were considered necessary. In Phase I, the 70-day feedlot beef was priced at 89 percent of Choice and the other two treatments at 83 percent of Choice. Larger discounts were selected for Phase II beef, with the 70-day feedlot and grain-on-forage beef priced at 83 percent of Choice and the forage beef at 75 percent of Choice (Table 6).

A postage-paid evaluation form was attached to each package of LSU beef. Some 4,000 packages were marketed during Phase I and 3,655 packages during Phase II. Highly visible posters and LSU personnel stationed behind the meat counter encouraged purchasers to complete and return the forms. A total of 910 forms (23 percent) were returned from Phase I and 653 forms (18 percent) were returned from Phase II. Therefore, 1,563 purchasers (20.4 percent) responded to the request to evaluate LSU beef from Phases I and II.

Pricing Response

The evaluation form requested purchasers to indicate if they would buy comparable cuts at the same or higher prices (Table 6). Willingness to purchase a comparable cut at the same price, in Phase I, was expressed by 86 and 88 percent of the responding purchasers for forage-finished and 70-day feedlot beef, respectively. Seventy-eight percent of the purchasers were willing to buy comparable cuts of grain-on-forage beef at the same price. Approximately 84 percent of the purchasers were willing to buy comparable cuts at equal prices for comparable treatments in Phase II. These results indicate a high level of satisfaction with the value of the product. Willingness to buy again at higher prices was greater in Phase I than in Phase II, averaging, for the three treatments, nearly 28 percent for Phase I and slightly more than 23 percent for Phase II. More than one-fourth of the responding purchasers thus indicated they had received a bargain when they purchased the LSU beef.

Purchaser Evaluations

Responding purchasers also ''rated'' their cuts on the basis of tenderness, flavor, juiciness, and overall acceptability (Table 7).[10] Differences in purchaser ratings among treatments were small. Statistically significant differences were confined to flavor and juiciness in Phase I, and to tender-

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[10] Ratings in Table 7 indicate the purchasers' evaluation of these four characteristics based on an hedonic (satisfaction) scale in which 1 is the most favorable rating.

Table 6.—Consumer response to prices, LSU Beef Marketing Study, Phases I and II

Treatment and phase	LSU price as percentage of price of Choice beef	Percentage of purchasers willing to buy comparable cuts at:	
		Same price	Higher price
Forage			
I	86	86	31
II	75	84	22
Grain on forage			
I	86	78	27
II	83	83	23
Feedlot			
I			
63 days	89	81	20
78 days	89	88	25
108 days	89	84	22
II			
70 days	83	84	23
140 days	95	70	16

Table 7.—Purchaser ratings of LSU beef by feeding treatment, LSU Beef Marketing Study, Phases I and II

	Rating and phase[1]							
	Tenderness		Flavor		Juiciness		Overall	
Treatment	I	II*	I*	II*	I*	II	I	II
Forage	1.63	2.28	1.60	2.37	1.64	2.32	1.62	2.25
Grain on forage	1.78	2.15	1.78	2.16	1.83	2.26	1.77	2.18
Feedlot								
63 days	1.71	—	1.65		1.74	—	1.71	—
70 days	—	1.95	—	2.13	—	2.08	—	2.01
78 days	1.66	—	1.58	—	1.66	—	1.60	—
108 days	1.66	—	1.61	—	1.60	—	1.65	—
140 days	—	2.23	—	2.27	—	2.33	—	2.30

[1] Phase I, 3-point hedonic scale, 1 = highest rating; Phase II, 5-point hedonic scale, 1 = highest rating.
*Ratings significantly different among treatments at $P < .05$.

ness and flavor in Phase II.[11] Purchasers gave their least favorable ratings to beef finished with grain on forage in Phase I, and to forage-finished beef in Phase II. Overall acceptability ratings among treatments did not differ significantly in either of the phases. ''Significant differences'' in ratings indicate purchasers could distinguish differences in the beef, presumably due to the different methods of feeding (treatments). However, the level of acceptability of the beef is indicated in the absolute value of the rating (number). The ratings show the purchasers found very little difference between any of the feeding treatments (none whatsoever in overall acceptability). And even more important, all ratings were in the lower (favorable) end of the hedonic rating scale.

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[11] Unless otherwise designated, the level of significance used was the .05 level. This means the probability is less than 5 percent, or one chance in 20, that differences in purchaser ratings among treatments could have occurred by chance. The purchaser ratings, therefore, indicate their perception of "real" differences, presumably due to differences in feeding treatments.

The purchaser evaluations can be summed up rather simply. Responding purchasers were able to detect some differences in the beef among feeding treatments. Average ratings were similar among feeding treatments. While favoring the 70-day feedlot beef, purchasers found forage-finished beef acceptable. The significance levels for the four evaluation criteria for treatment effects, store effects, and their interaction are shown in Appendix Table 2.

Household Panel

Procedures

The household ''consumer'' panel, composed of representative beef consumers, is another important means of evaluating the consumer's ultimate acceptance of beef. Unlike the retail purchaser group, the household panel includes individuals (husbands and wives) who purchase and consume only specific grades and types of beef, along with others whose purchases are normally influenced by price and/or curiosity. Household panels consist of untrained members who naturally reflect personal bias and prejudice in their ratings. The household panel, however, represents the beef-consuming public.

Household panels for each of the three phases of this study were selected in the same manner. The *Pope City Directory* for Baton Rouge was used to develop geographical clusters of households, each cluster containing approximately 150 households. Samples of 15, 27, and 17 clusters were randomly selected to obtain panels of 150, 273, and 168 households for Phases I, II, and III, respectively (approximately 10 households were randomly selected from within each cluster). Each household selected included a husband and wife who regularly consumed beef and who were physically present during the 3-week testing period. Each homemaker (wife) gave her age, educational attainment, and an estimate of family income during an interview. These personal characteristics for the three panels are summarized in Appendix Table 3.

The homemaker also indicated to the interviewer when she had last knowingly served forage-finished beef in her home. Nearly 17 percent of the homemakers said they had served forage-finished beef in the previous

12-month period, and another 8 percent indicated it had been served in their homes but not within a year. The remaining 75 percent indicated they had never knowingly served forage-finished beef in their homes.

Each household in the three phases of the study received, free of charge, two loin, two round, and two chuck steaks delivered two at a time over a 3-week period. Both members of a household during a particular delivery received steaks from the same position on the wholesale cut, but from different carcasses. The husband's steak was identified with a metal ring clamped to the steak. Panel members were advised of feeding treatments that produced particular steaks only in Phase I.

Panel members were allowed to prepare the steaks in any manner they preferred, so long as the identity of the steaks was not lost. With the exception of artificial tenderizers, any flavorings or sauces could be added.

Household (Consumer) Evaluations

An evaluation form was delivered with each steak and picked up a week later. Panel members rated the steaks on tenderness, flavor, juiciness, and overall acceptability (except Phase I, when juiciness was not evaluated). Panel member cooperation was excellent.

Acceptance ratings of the three household panels for the four characteristics evaluated are shown in Table 8. Differences in consumer ratings among treatments were relatively small in each phase. Significant differences in ratings among treatments were confined to tenderness in Phase I, and to tenderness, flavor, and juiciness in Phase II. Weight differences among treatments explain much of the discriminatory ability of the Phase II panel. The forage-finished steers averaged 837 pounds liveweight, indicating some animals weighed less than 800 pounds. Steers from the feedlot treatments averaged 932 pounds, indicating most animals weighed 900 or more pounds at slaughter. When animal weight among treatments was held constant and the animals were more mature, as occurred in Phase III, no differences among treatments were reported by the consumer panel. The significance levels of the treatment effects for the four criteria for the three phases are shown in Appendix Table 4. Two important results should be noted from acceptance ratings of the household panel. First, numerical differences in average acceptance ratings among treatments were very small (Table 8). For example, the range in overall acceptability ratings among Phase II treatments was from 2.33 (forage finished) to 2.01 (70 days feedlot) based upon a 7-point hedonic scale. Second, all ratings were in the lower (acceptable) end of the rating scale.

Results from the household panel evaluations indicate that (1) panel members were able to detect some real differences in the beef, presumably due to differences in feeding treatments; (2) panel members generally favored beef from steers finished with some grain; (3) panel member

Table 8.—Household panel ratings by feeding treatment, LSU Beef Marketing Study, Phases I - III

Treatment and phase	Ratings[1]			
	Tenderness	Flavor	Juiciness	Overall
Forage				
I	3.11*	2.03	—[2]	3.15
II	3.27*	3.10*	3.16*	2.33
III	3.23	2.94	2.95	2.43
Grain on forage				
I	2.89*	1.94	—[2]	3.02
II	3.13*	3.11*	2.95*	2.25
III	3.17	2.88	3.13	2.34
Feedlot				
I				
63 days	3.11*	1.89	—[2]	3.08
78 days	2.67*	1.92	—[2]	2.89
108 days	2.61*	1.87	—[2]	3.00
II				
70 days	2.65*	2.91*	2.78*	2.01
140 days	2.75*	2.92*	2.80*	2.20
III				
70 days	3.16	2.76	2.88	2.32
60-70[3]	3.24	2.98	3.05	2.53

[1] 7-point hedonic scale, 1 = highest rating, except Phase I overall where 9-point hedonic scale was used.
[2] Not evaluated.
[3] 60 days of 1% grain on forage followed by 70 days feedlot.
*Ratings significantly different at $P<.05$.

distinctions among feeding treatments were relatively small, and (4) panel members found beef from forage treatments in Phases I and III (slaughter weight 1,000 pounds or greater) quite acceptable.

Methods used by household panel members in cooking their steaks explained some of the variation in their ratings (Table 9). Methods used by panel members in preparing steaks included broiling, grilling, pan frying, braising, or cooking them in liquid. Broiling was the most popular method. Highest ratings were given to steaks cooked in liquid, and lowest ratings to steaks grilled or pan fried. Ratings among cooking methods for Phase III beef were significantly different, however, only for juiciness and overall acceptability. Significant differences in ratings among cooking methods for Phase II beef were found for flavor, juiciness, and overall acceptability.

Influence of Socioeconomic Factors

Consumer ratings are influenced by factors other than the steak and how it is prepared. These exogeneous factors, so called because they are apart from the product, cannot be changed by the beef industry. These factors

Table 9.—Household panel ratings by cooking method, LSU Beef Marketing Study, Phase III

Cooking method	No. of observations	Rating[1]			
		Tenderness	Flavor	Juiciness*	Overall*
Broiled	354	3.17	2.84	2.91	2.32
Grilled	223	3.53	2.94	3.11	2.63
Pan fried	113	3.34	3.06	3.11	2.53
Braised	240	3.04	2.88	3.07	2.32
Cooked in liquid	73	2.77	2.85	2.83	2.30

[1] 7-point hedonic scale, 1 = highest rating.

*Ratings were significantly different among cooking methods at $P<.05$. Flavor, juiciness, and overall acceptability ratings were significantly different among cooking methods in Phase II. Information on cooking methods was not determined in Phase 1.

can lead to higher or lower ratings, depending upon how they affect the consumer-product relationship. Consumer panel members differed by age, educational level, family income, race, and previous experience with forage-finished beef. Knowledge of the influence of these factors on panel member ratings is useful in analyzing potential markets and the need for promotion and/or product modification in particular markets.

Phase III household consumer panel ratings for tenderness, flavor, juiciness, and overall acceptability, categorized by the homemaker's age, level of education, family income, race, and previous experience with forage-finished beef in the home, are shown in Table 10. Ratings differed significantly among homemakers of different ages for the four palatability traits evaluated. Younger homemakers (less than 40 years of age) and homemakers within the 50-59 year age range gave the most unfavorable ratings, while those aged 60 years or older were most pleased with the steaks as they had prepared them.

Ratings also differed significantly by level of education. Homemakers with an elementary level education gave the highest ratings, while homemakers with college training gave the least favorable ratings. These results suggest that homemakers with more formal education tend to be more discriminatory and critical.

Another factor on which ratings differed significantly was family income. Members of households with annual family incomes of less than $10,000 gave the most favorable ratings for the LSU beef. Households earning $20,000 or more per year were generally least favorable in their ratings. This may suggest that lower income panel members were better acquainted than higher income members with the beef they were asked to evaluate.

Phase III consumer panel results differed somewhat from those of the previous two phases in that ratings differed significantly for age, education, and income. Household panel ratings in Phases I and II did not differ

Table 10.—Household panel ratings by homemakers' age, homemakers' level of education, family income, race, and experience with forage-finished beef, LSU Beef Marketing Study, Phase III

Factor	No. of observations	Ratings[1] Tenderness	Flavor	Juiciness	Overall
Homemakers' age*					
Less than 30	220	3.53	2.92	3.28	2.50
30-39	304	3.28	3.13	3.03	2.77
40-49	198	2.92	2.80	2.76	2.11
50-59	190	3.33	2.94	3.14	2.40
60-65	46	2.56	2.35	2.69	1.54
More than 65	50	2.50	2.02	2.44	1.24
Homemakers' education*					
Elementary	110	2.65	2.43	2.38	1.81
High school	306	3.33	2.84	2.98	2.36
College	464	3.34	2.98	3.17	2.60
Other[2]	128	2.87	3.08	3.00	2.34
Family income*					
Less than $10,000	150	2.87	2.47	2.20	1.82
$10,000-$19,999	342	3.07	2.81	2.98	2.35
$20,000-$29,999	308	3.44	3.09	3.38	2.60
$30,000-$50,000	174	3.36	2.99	3.07	2.66
More than $50,000	34	3.09	3.29	3.32	2.50
Race*					
White	756	3.40	2.98	3.20	2.58
Black	252	2.24	2.64	2.42	1.89
Forage*[3]					
Yes	250	2.92	2.55	2.72	2.11
No	758	3.29	2.90	3.10	2.50

[1] 7-point hedonic scale, 1 = highest rating.

[2] Includes business school, nursing, vocational-technical school, etc.

[3] Forage category indicates ratings of panel members who had previously consumed forage-finished beef in their homes (yes) and members who had not (no). This factor was determined only from the Phase III panel.

*Ratings were significantly different ($P < .05$) in Phase III, except tenderness ratings did not differ due to experience with forage-finished beef. In Phase II, juiciness and overall ratings differed significantly due to race; flavor, juiciness, and overall ratings differed significantly among cooking methods; and overall ratings differed significantly among income levels. In Phase I, tenderness and overall ratings differed significantly due to race.

significantly for these three factors, with the exception of Phase II when overall acceptability ratings differed significantly among income levels. This could be partially explained by the smaller number of categories used for income in Phase I and age of homemaker in Phase II (see Appendix Table 3).

Phase III panel ratings differed significantly on the basis of race for the four palatability traits measured (Table 10). White panel members were considerably less favorable than black panel members in rating the LSU beef. These findings agree, in general, with those of the household panels in the two previous phases.

During the initial interview to select Phase III panel members, each homemaker indicated whether or not she had, with certain knowledge, prepared and served forage-finished beef in her home. The average ratings of panel members who had previously consumed forage-finished beef and those who had not are given in Table 10. Panel members with previous experience with forage-finished beef gave significantly higher ratings to the LSU beef for all traits except tenderness. Palatability characteristics of beef finished with less grain than is normally consumed by animals attaining Choice grade apparently met the needs of this group of consumers.

It is important to note that, within these five socioeconomic factors, differences in average ratings were numerically small. And in every case, the average ratings were in the favorable end of the 7-point scale.

Household panel ratings by sex of panel member and by USDA quality grade of the beef are given in Table 11. No significant differences were found among ratings for either of these two factors. Each of the ratings was in the favorable end of the rating scale. Even though the beef differed in quality grade from Standard to Prime, the household panel in Phase III was unable to detect "real" differences due to quality grade in the steaks they evaluated.

Table 11.—Household panel ratings by sex and quality grade, LSU Beef Marketing Study, Phase III

Factor	No. of observations	Ratings[1]			
		Tenderness	Flavor	Juiciness	Overall
Sex					
Male	504	3.20	2.92	3.05	2.42
Female	504	3.20	2.87	2.96	2.40
Quality grade					
Standard	89	3.13	2.98	3.09	2.44
Good	647	3.25	2.89	3.02	2.42
Choice	253	3.17	2.88	2.96	2.39
Prime	18	2.55	2.94	2.83	2.11

[1] 7-point hedonic scale, 1 = highest rating.

Household Pricing Response

Each steak evaluation form provided to household panel members indicated the average regular retail price in Baton Rouge supermarkets at that time for USDA Choice beef of the same cut that panel members received. These prices were $2.99, $1.99, and 99 cents per pound for loin, round, and chuck steaks, respectively (Table 12). As indicated previously, steaks

Table 12.—Household panel pricing response by type of steak, LSU Beef Marketing Study, Phase III[1]

	Type of steak		
Item	Loin	Round	Chuck
	Dollars		
Avg. retail price (USDA Choice)[2]	2.99	1.99	0.99
Avg. panel suggested price[3]	2.34	1.67	1.02
Treatment			
Forage	2.37	1.58	0.98
Grain on forage	2.42	1.65	1.00
70 days feedlot	2.26	1.75	1.06
60-70[4]	2.30	1.69	1.03
Race[5]			
White	2.32	1.62	0.96
Black	2.38	1.81	1.18
Cooking method			
Broiled	2.32	1.71	1.09
Grilled	2.34	1.60	0.96
Pan fried	2.22	1.80	1.03
Braised	2.55	1.62	0.98
Cooked in liquid	2.24	1.64	1.06
Quality grade[6]			
Standard	2.27	1.54	0.88
Good	2.34	1.62	1.00
Choice	2.35	1.78	1.04
Prime	2.22	2.40	0.97
Income[7]			
Less than $10,000	2.48	1.82	1.25
$10,000-$19,999	2.37	1.72	0.98
$20,000-$29,999	2.20	1.55	0.97
$30,000-$50,000	2.42	1.66	0.96
More than $50,000	2.18	1.55	1.15
Education[8]			
Elementary	2.60	1.89	1.33
High school	2.35	1.68	1.00
College	2.27	1.66	0.98
Other[9]	2.30	1.49	0.93

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[1] Consumer panel members in Phase I were not asked any questions concerning prices. Phase II members were requested to indicate whether they would or would not purchase steaks they had evaluated at "normal supermarket prices."

[2] These prices were obtained from a major food chain in the Baton Rouge area.

[3] Average prices panel members were willing to pay for each cut based on suggested retail price for Choice beef and their evaluation of the LSU steaks.

[4] 60 days of 1% grain on forage followed by 70 days feedlot.

[5] Prices were significantly different ($P<.05$) between races for round and chuck steaks.

[6] Prices were significantly different ($P<.05$) among quality grades for round steaks.

[7] Prices were significantly different ($P<.05$) among income levels for round and chuck steaks.

[8] Prices were significantly different ($P<.05$) among education levels for round and chuck steaks.

[9] "Other" includes business school, nursing, vocational-technical school, etc.

were provided free to panel members. However, panel members were requested to "write-in" the values of the steaks based upon "suggested" retail prices and their own evaluation of the steaks. Consumer "write-in" prices were expected to be less than the suggested retail prices, and they were, except for chuck steaks. Panel members valued loin steaks at $2.34 per pound, round steaks at $1.67 per pound, and chuck steaks at $1.02 per pound.

Household consumer "write-in" prices by feeding treatment are shown in Table 12. While there were absolute differences in "write-in" prices for each of the three cuts among treatments, these differences were not statistically significant. Panel member prices for individual cuts differed widely among individual carcasses, which may have obscured some of the treatment effect. These results indicate that even though the household panel may have picked up some differences in value among treatments, these differences were so small that they could have been due to chance. Essentially, the household panel could not distinguish any "real" differences in value among forage treatments and grain treatments.

"Write-in" prices by black panel members and white panel members differed significantly for round steaks and chuck steaks. Black panel members consistently placed a higher value than white panel members on both round and chuck steaks.

Consumer suggested prices were expected to differ significantly among cooking methods. However, they did not (Table 12).

Quality grade is usually considered a highly explanatory factor in beef pricing. A premium price is consistently demanded for the higher grades. While panel suggested prices tended to rise with quality grade, differences in prices among grades were significant only for round steaks.

Income and education significantly influenced household panel "write-in" prices for round and chuck steaks. "Write-in" prices tended to decrease as income and level of education increased. The more affluent and more educated members were less inclined to pay regular supermarket prices for the LSU beef than were the less affluent and less educated panel members.

Laboratory Taste Panel

Procedures

Meat from each phase of the study was evaluated by a trained laboratory taste panel. The panels were selected from a group of LSU employees and graduate students on the basis of tasting abilities. After selection, members completed a training course in which cuts of different quality and taste were evaluated. During training, members scored samples individually, then compared and reconciled ratings. When it became evident that the panel members had developed a common basis for rating samples and were uniformly using the rating scales, testing began. Six members constituted a panel, except for Phase III when a five-member panel was used.

The organoleptic qualities rated were tenderness, flavor, juiciness, and overall acceptability. The scoring system was a 7-point hedonic scale with a lower numerical rating representing a more desirable score.

Cuts selected for evaluation in Phases I and II were loin steaks, rib roasts, and round steaks. In Phase III, only loin steaks were evaluated. Therefore, this report only presents data pertaining to loin steaks.[12] Care was taken to obtain steaks from the same location on each carcass, with the ninth and tenth loin steaks from the anterior end of the loin being selected for evaluation in Phases I and II. Steaks from both the right and left loin were used in Phase III (the first and third loin steak from the anterior end of the right loin and the second and fourth steaks from the anterior end of the left loin). In Phases I and II, the steaks were cut from wholesale loins that had been frozen earlier. In Phase III, loin steaks were evaluated fresh and after freezer storage for 70 days and 208 days.

In preparation for cooking, the steaks were thawed at refrigerator temperature (3-4°C) for 24 hours and then brought to room temperature (26°C). In Phases I and II, the steaks were broiled on one side for about 12 minutes to an internal temperature of 40-45°C, turned, and broiled on the other side for about 10 minutes to an internal temperature of 70°C. Oven racks were adjusted so that the tops of the steaks were approximately 6 inches from the heating element. For Phase III, the steaks were baked without turning in a conventional kitchen-type oven that had been preheated to 175°C. The internal temperature of each steak was continually monitored by a Honeywell multipoint potentiometer, and steaks were removed from the oven at an internal temperature of 70°C. After removal from the oven, all fat was trimmed and the steak was cut in such a manner that panel members received their portion from the same position each day. Panel members were served apple slices and water between samples.

Results

Results of laboratory taste panel evaluations of loin steaks from Phase I are shown in Table 13. Treatment differences were significant for tenderness, flavor, and overall acceptability. Apparently, differences among these three characteristics were due to the grain-on-forage treatment being significantly less tender, flavorful, and less acceptable. A comparison of the forage-only treatment *vs.* the feedlot treatments showed no significant differences. The tenderness score for the forage-only treatment was 2.98, while the average score for the three feedlot treatments was 3.02. Although juiciness was not significantly affected by treatment, the grain-on-forage treatment received a less desirable mean juiciness score than the other treatments.

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[12] Data and discussion of laboratory taste panel evaluations of roasts and round steaks are included in DAE Research Reports Nos. 503 and 509 *(9, 10)*.

Results of taste panel evaluations of loin steaks from Phase II are shown in Table 14. Tenderness was not significantly affected by feeding treatment. A significant effect of treatment on flavor, juiciness, and overall acceptability was evident, and orthogonal comparisons showed this difference to be between the forage-only treatment and the two feedlot treatments. The forage-only feeding treatment produced beef that the laboratory taste panel found to be less flavorful, less juicy, and lower in overall acceptability than beef from the two feedlot treatments.

Results from Phase III and an analyses of variance of the data are shown in Tables 15 and 16, respectively. Due to the prolonged length of the forage finishing treatment in this phase, some panel members were unable to

Table 13.—Laboratory taste panel mean organoleptic scores by feeding treatment, loin steaks, LSU Beef Marketing Study, Phase I

	Rating[1]			
Treatment	Tenderness*	Flavor**	Juiciness	Overall acceptability*
Forage	2.98	3.08	2.55	3.05
Grain on forage	3.50	3.32	2.62	3.35
63 days feedlot	3.05	2.98	2.47	2.98
78 days feedlot	3.22	3.17	2.53	3.17
108 days feedlot	2.78	2.75	2.30	2.83

[1] 7-point hedonic scale, 1 = highest rating.
*Ratings significantly different at $P<.05$.
**Ratings significantly different at $P<.01$.

Table 14.—Laboratory taste panel mean organoleptic scores by feeding treatment, loin steaks, LSU Beef Marketing Study, Phase II

	Rating[1]			
Treatment	Tenderness	Flavor**	Juiciness*	Overall acceptability**
Forage	3.82	4.23	4.17	4.36
Grain on forage	3.91	3.83	3.85	4.04
70 days feedlot	3.55	3.57	3.85	3.73
140 days feedlot	3.78	3.56	3.60	3.94

[1] 7-point hedonic scale, 1 = highest rating.
*Ratings significantly different at $P<.05$.
**Ratings significantly different at $P<.01$.

Table 15.—Laboratory taste panel organoleptic scores by feeding treatment and length of freezer storage, loin steaks, LSU Beef Marketing Study, Phase III

Feeding treatment	Storage[2]	Rating[1] Tenderness	Flavor	Juiciness	Overall acceptability
Forage	Fresh	2.66	2.49	2.77	2.83
	Short freeze	3.37	3.06	2.77	3.29
	Long freeze	3.29	3.81	3.52	3.76
	Mean	3.08	3.01	2.94	3.22
Grain on forage	Fresh	2.40	3.03	2.37	2.71
	Short freeze	2.89	2.54	1.69	2.82
	Long freeze	3.43	2.44	2.97	3.11
	Mean	2.90	2.67	2.34	2.88
70 days feedlot	Fresh	3.63	3.14	3.66	3.46
	Short freeze	2.61	2.00	2.68	2.42
	Long freeze	2.69	2.69	3.37	2.80
	Mean	3.00	2.63	3.26	2.91
60-70[3]	Fresh	4.46	3.79	3.46	4.11
	Short freeze	3.26	2.91	2.74	3.14
	Long freeze	4.51	3.54	4.00	4.20
	Mean	4.08	3.41	3.40	3.82

[1] 7-point hedonic scale, 1 = highest rating.

[2] Short freeze = 70 days storage; long freeze = 208 days storage.

[3] 60 days of 1% grain on forage followed by 70 days feedlot.

Table 16.—Laboratory taste panel analyses of variance, LSU Beef Marketing Study, Phase III

Source	D.F.	Trait Tenderness	Flavor	Juiciness	Overall acceptability
Treatment	3	**	**	**	**
Freezing	2	**	**	**	**
Treatment-freeze	6	**	**	*	**
Error	322				

*Significantly different at P<.05.

**Significantly different at P<.01.

participate in evaluations near the end of the experiment. Therefore, data from only half the steers in each treatment are presented in Phase III (7 instead of 14).

Both feeding treatment and freezing had a highly significant (P<.01) effect on all organoleptic qualities evaluated. Also, a significant interaction between treatment and freezing was observed for all organoleptic qualities. When compared with fresh beef, freezing and storage of beef from forage-fed animals resulted in less desirable ratings for all attributes evaluated. However, freezing and storage of beef from 70-day feedlot animals resulted in more desirable organoleptic scores for all variables evaluated. The other two feeding treatments responded somewhat erratically to freezing. In some instances ratings were more desirable, and in other instances they were less desirable.

Although many of the laboratory panel ratings differed significantly among feeding treatments, most treatments received ratings that were higher than the middle of the scale used. This indicates that no feeding treatment or storage interval yielded beef that was rated as undesirable.

Economic Feasibility

Most cattlemen are businessmen. They expect to earn a profit from their cattle operations. Programs that promise highest net returns in good times and minimum losses in poor times are, therefore, of interest to them. Feeding programs used in this study were designed to reduce total feed costs by substituting forages for the more expensive feed grains. Unfortunately, the price depressing oversupply of beef throughout the period of the study created a loss minimization situation from Phase I through Phase III.

Records maintained during the study were used to develop costs of producing the slaughter steers—from conception through finishing (Col. 1, Table 17).[13] Costs per pound of forage-produced carcasses were 66 cents, 80 cents, and 92 cents for Phases I, II, and III, respectively. Higher costs in the latter two phases resulted from less favorable rates of gain, higher fertilizer costs, and, for Phase III, the heavy slaughter weight. Costs of producing grain-on-forage carcasses were 69 cents, 83 cents, and 89 cents per pound for Phases I, II, and III, respectively. Higher grain-on-forage treatment costs in Phases II and III resulted from poorer gains, increased grain ration costs, and higher forage production costs. Costs of producing beef from the 70-day feedlot treatment were 76 cents, 84 cents, and 81 cents per pound for Phases I, II, and III, respectively. Costs were higher in Phase II due to a large increase in grain prices, which had dropped somewhat prior to Phase III. The fourth treatment in Phase III (60 days of 1 percent grain on forage, then 70 days feedlot) had production costs of 85 cents per pound.

Some beef from all phases was sold on a graded carcass basis. This method of marketing, based on "Yellow Sheet" pricing, is commonly termed on-the-rail selling. Graded carcass prices (Col. 2, Table 17) did not cover costs of producing the steers in any of the treatments or phases.

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[13] Detailed budgets are available from the authors. Costs of marketing, custom slaughter, and management were excluded.

Table 17.—Economic feasibility of treatments, LSU Beef Marketing Study, Phases I-III

Treatment and phase	Cost/lb. carcass[1] ($)	Graded carcass price/lb.[2] ($)	Retail cutout[3] (%)	Cost/lb. cutout ($)	Cost/lb. retail[4] ($)	Composite retail price/lb.[5] ($)
Forage						
I	.66	.54	71.2	.93	1.16	1.21
II	.80	.65	72.4	1.10	1.37	1.30
III	.92	.58	—	—	—	—
Grain on forage						
I	.69	.54	70.4	.98	1.22	1.21
II	.83	.70	70.4	1.18	1.47	1.45
III	.89	.61	—	—	—	—
Feedlot						
I						
63 days	.76	.55	71.0	1.07	1.34	1.24
78 days	.76	.55	70.0	1.08	1.35	1.24
108 days	.84	.54	70.6	1.19	1.49	1.24
II						
70 days	.84	.74	69.2	1.21	1.51	1.45
140 days	.89	.75	68.5	1.30	1.62	1.55
III						
70 days	.81	.61	—	—	—	—
60-70[6]	.85	.61	—	—	—	—

[1] Detailed cost budgets are available from the authors. Excludes marketing, custom slaughter, and managerial charges.

[2] Based upon graded carcass prices quoted in the "Yellow Sheet."

[3] Cutability is based upon estimated USDA Yield Grade.

[4] A 25% markup was added to cutout cost to cover retail expense.

[5] Average retail price for all beef sold at retail from the beef carcass.

[6] 60 days of 1% grain on forage followed by 70 days feedlot.

Losses per pound ranged from 12 to 34 cents for the forage treatment, from 13 to 28 cents for the grain-on-forage treatment, and from 10 to 20 cents for the 70-day feedlot treatment. The fourth treatment in Phase III lost 24 cents per pound. The forage treatments, particularly, were penalized by this method of pricing due to their lower quality grades.

As mentioned previously, the LSU beef was test marketed in retail supermarkets during Phases I and II. This method of marketing, not available to most producers, probably maximized returns for the product. It did, however, eliminate any bias in the product's price that could have been introduced by intermediaries in the marketing system.

Costs of the LSU beef at the retail level were estimated by adjusting carcass costs for retail cutability and adding a retail markup. Cutability estimates for the five USDA Yield Grades reported by the USDA Meat Animal Research Center at Clay Center, Nebraska *(8)* were used to convert carcass costs to costs per pound of retail beef (Cols. 3 and 4, Table 17). Then, to determine the cost per pound of retail cuts (Col. 5, Table 17), a 25 percent retail markup was added. Retail cut prices for Phases I and II, respectively, were $1.16 and $1.37 for forage beef; $1.22 and $1.47 for beef from grain on forage, and $1.35 and $1.51 for the 70-day feedlot beef. The USDA estimated price for Choice retail beef *(13)* was $1.29 per pound in February 1975 and $1.52 per pound in October 1975 (Phase II).

Actual retail prices charged for the steaks and roasts, along with the store's regular retail price for other cuts marketed from the carcasses (primarily ground beef and stew meat), were used to develop composite retail prices for each treatment in Phases I and II (Col. 6, Table 17). These prices, which may have been below the market clearing price, did not cover the combined costs of producing and retailing the LSU beef for any treatment except the forage treatment in Phase I.

Limitations

A number of points should be kept in mind in interpreting the findings from this three-phase study:

1. The test animals were produced and finished on one of the branch locations of the Louisiana Agricultural Experiment Station. Breeding, management practices, labor availability, forage quality, and livestock equipment at these branch stations differ considerably from that of the typical beef operation. This has considerable meaning to commercial beef producers. The combination of high-quality animals and high-quality pastures produced the highly rated beef in this study. Lower quality animals and/or pastures would not be likely to produce beef with such high acceptability.
2. The Phase III consumer panel evaluated beef that had been vacuum packaged, frozen, and stored for periods ranging from 6 weeks to 9 months. Acceptance (ratings) may have been influenced by length of storage to a different degree for specific animals and/or treatments.
3. The reputation of the cooperating food retailer and of LSU may have introduced some bias into the retail ratings. This bias could not be measured and/or removed. Household (consumer) panel members may have given more favorable ratings in an attempt to compensate for the absence of charges for the meat. There is no reason to expect that these biases materially influenced ratings on other than an absolute basis, however.
4. The Phase III laboratory panel met over a period exceeding 15 months for training and evaluation. The panel also evaluated fresh, short frozen, and long frozen samples on an alternating basis. Some of the variations in panel ratings could be explained by these factors.
5. The consumer panel was composed of representative Baton Rouge

residents. Their evaluations should be representative of a large proportion of the population. However, tastes and preferences for the beef evaluated in this study may differ for some consumers in other areas of the state or nation.

6. The option of marketing beef cattle on other than a liveweight basis may not be available to all producers. Returns to marketing forage-finished and limited-grain-finished cattle for slaughter may be unfavorable for producers with markets limited to live sales.

7. Consumer tastes and preferences for beef are subject to change over time. Purchasers and their consumption are influenced by the availability and price of beef and other competing meats.

8. The attitudes held by a limited number of marketmen toward the marketability of forage-finished and limited-grain-finished beef are unfavorable. Opportunities for marketing beef at retail, as was done in this study, will be limited when these individuals constitute the market. However, results of this study suggest that a different viewpoint is in order.

9. The extension of beef production into the stocker and finishing levels usually demands facilities, finances, and management skills not required at the cow-calf level.

10. While some of the differences in household and laboratory panel ratings among phases within feeding treatments could have been due to differences in the panels and their training, these differences could not be measured and/or removed.

Summary

A three-phase, cooperative research project was begun in late 1974 in an attempt to determine the marketability and consumer acceptability of beef from cattle finished on forage alone or with limited grain, and the economic feasibility of producing this type of beef.

Phase I of the project included five feeding treatments, each including 10 steers: forage, one-half percent grain on forage, 63 days feedlot, 78 days feedlot, and 108 days feedlot. Four treatments were evaluated in Phase II: forage, 1 percent grain on forage, 70 days feedlot, and 140 days feedlot (the latter included 16 steers only, the other three treatments included 16 steers *and* nine heifers each). Phase III had four treatments including 14 steers each: forage, 1 percent grain on forage, 70 days feedlot, and 60 days grain on forage followed by 70 days feedlot.[14] In total, 170 steers and 27 heifers were produced, slaughtered, and evaluated in the course of this study. The animals were of excellent breeding and were finished on high-quality forages and/or grain rations. Phase I steers were slaughtered in February 1975, and Phase II steers and heifers in October 1975. Phase III steers were slaughtered when the average liveweight in each treatment was 1,050 pounds (actual slaughter ranged from October 1976 to April 1977).

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[14] The forage, grain-on-forage, and 78-day feedlot treatments in Phase I, the forage, grain-on-forage, and 70-day feedlot treatment steers in Phase II, and the four treatments in Phase III are discussed in both the body and summary of this report.

Live Animal and Carcass Characteristics

Treatments involving grain achieved the highest average daily gains. Gains on forage with supplemental grain averaged about 1.8 pounds per day, compared with 2.7 pounds per day on full feed in feedlot (Phase III). Slaughter in October for Phase II resulted in unfavorable gains on forage and reduced feed efficiency in the feedlot.

Shrinkages from the West Louisiana Experiment Station to the slaughter plant, approximately 190 miles, were 8.1, 7.4, and 6.8 percent, respectively, for the forage, grain-on-forage, and 70-day feedlot treatments. Dressing percentages averaged around 55 percent, with the forage treatment having a somewhat lower dressing percentage than the other treatments. Average fat thickness did not exceed one-half inch for any treatment, with the smallest measurements being contributed by pasture treatments and the largest by treatments involving the largest total grain consumption. Ribeye areas ranged from 9.8 to 11.7 square inches, with Phase I treatments having the largest areas.

Yield grades ranged from 1.9 to 3.2, indicating all treatments had desirable cutability. Yield grade increased (cutability decreased) as the amount of grain consumed increased. Quality grade also responded positively to grain consumption. The 70-day feedlot treatment consistently produced the largest number of Choice carcasses, and the forage treatments the least. Marbling scores were consistent with the quality grade findings.

Warner-Bratzler Shear scores did not differ significantly among feeding treatments in any phase. The forage and grain-on-forage treatments produced carcasses with more yellow colored fat than did the 70-day feedlot treatment.

Consumer Acceptance

Consumer acceptability of the LSU beef was evaluated by (1) a "purchaser" panel composed of customers who had purchased steaks and roasts from a cooperating retail food chain, (2) a household panel that received steaks free of charge, and, (3) a laboratory "taste" panel that had been trained to evaluate beef. The "purchaser" panel included 910 purchasers in Phase I and 653 in Phase II. The household panel included 150 households in Phase I, 291 in Phase II, and 168 in Phase III for a total of 609 households (1,218 individuals) for the three phases. The laboratory panel was composed of five persons in Phases I and III and six persons in Phase II.

Purchaser Panel. — The cooperating food chain processed much of the carcasses in Phases I and II and offered steaks and roasts for sale in three Baton Rouge stores. Purchasers indicated whether they would or would not make repeat purchases at the same or higher prices. While slight differences existed among feeding treatments, approximately 87 and 83 percent of the purchasers were willing to make repeat purchases at the same price for beef in Phases I and II, respectively. A smaller percentage of purchasers were willing to purchase again at higher prices (28 percent in Phase I and 23 percent in Phase II). Purchasers were highly satisfied with the value received, and many purchasers considered the beef underpriced.

Tenderness, flavor, juiciness, and overall acceptability were evaluated by the responding purchasers. Differences in numerical ratings among treatments were small in all phases. Average ratings were all within the favorable range of the evaluation scale. Significant differences among treatments for overall acceptability were not found in either phase. Purchasers, therefore, found beef from steers finished on forages, forages with grain, or 70 days in feedlot almost equally acceptable. This suggests an inability of purchasers to discriminate among the feeding treatments, little real differences in beef from the three feeding treatments, or some combination of these.

Household Panel.— Individual household (consumer) panels selected from within the City of Baton Rouge evaluated steaks from all animals in each phase. Each household (husband and wife) received, free of charge, two loin, two chuck, and two round steaks. Household panel members rated the steaks on the basis of tenderness, flavor, juiciness, and overall acceptability. Significant differences in ratings among treatments were found for tenderness in Phase I, and for tenderness, flavor, and juiciness in Phase II. The household panel detected real differences among the feeding treatments in the beef from the first two phases. No significant differences in ratings were found in Phase III, when the animals in each treatment weighed approximately the same at slaughter. The absolute value of the average hedonic ratings for all feeding treatments were numerically close for all phases,. In every case the hedonic ratings for all treatments were in the favorable end of the scale. Thus, the household panel found forage-finished beef to be acceptable.

Method of steak preparation by the household panel had little influence on ratings. Steaks cooked in liquid received the most favorable ratings, and grilled and pan fried steaks the least favorable. However, ratings were significantly different among cooking methods only for juiciness and overall acceptability. All of the ratings were in the favorable end of the hedonic scale for all cooking methods.

Some of the differences in household panel ratings in Phase III could be explained by age, education, and family income of the households.

The younger members were the most critical, and the eldest the least critical. The panel members who were more highly educated and had higher incomes were more critical in their ratings. These same socioeconomic factors were not as explanatory of differences in ratings in Phases I and II.

White household panel members gave lower ratings than black members. Previous experience in preparing and consuming forage-finished beef in the home also led to improved ratings for all treatments.

Household panel members "valued" (priced) the steaks based upon local supermarket prices for USDA Choice in comparable cuts (given on the evaluation form) and their own evaluations of the steaks. USDA Choice beef prices given to the panel were $2.99, $1.99, and 99 cents per pound for loin, round, and chuck steaks, respectively. Average prices suggested by panel members for the loin, round, and chuck steaks were $2.34, $1.67, and $1.02 per pound, respectively. These prices did not differ significantly among feeding treatments. In other words, household panel members found steaks from forage-finished and grain-on-forage steers equal in dollar value to the same cuts from steers finished for 70 days in feedlot.

Panel "suggested" prices did not differ among methods of preparation. However, black panel members valued round and chuck steaks higher than white panel members. Prices of round steak were positively associated with quality grade, whereas loin and chuck steak prices were unresponsive to quality grade.

Education and income significantly influenced pricing by the panel. Household panel "suggested" prices dropped among panel members with higher incomes and more education. Interpretation of these pricing responses should be done with caution, however, as the suggested prices represent "intentions" and not "actual purchases."

Laboratory Taste Panel. — Trained laboratory taste panels were used to evaluate the organoleptic quality of beef from the various feeding treatments. Samples were rated for tenderness, flavor, juiciness, and overall acceptability.

Findings of the laboratory panel varied somewhat in different phases, but certain trends in the data are evident. When the animals were finished to a final weight of 1,000 to 1,050 pounds (Phases I and III), beef from steers finished on forage was rated at least equal in quality to beef from animals finished under feedlot conditions. Panel members rated samples higher than the middle of the scale and found all samples acceptable. In Phase II, when the forage-finished animals were significantly lighter than the grain-fed animals, some differences were observed and the grain-finished animals received more favorable scores. Although statistically significant, the differences observed were numerically small and mean scores for most of the treatments were higher than the middle of the scale, indicating good palatability and organoleptic quality.

Feasibility of Treatments

Experiment station records were used to develop estimated costs of producing the slaughter steers, from conception through finishing. Forage and grain-on-forage treatment costs rose from Phase I through Phase III. Costs of producing the forage-finished carcasses were 66 cents, 80 cents, and 92 cents per pound for Phases I through III, respectively. Costs of producing the grain-on-forage carcasses were 3 cents per pound higher than on forages alone. The 70-day feedlot treatment produced carcasses budgeted at 76 cents, 84 cents, and 81 cents per pound for Phases I through III, respectively. The combination of 60 days grain on pasture and 70 days in feedlot produced costs of 85 cents per pound in Phase III. In all cases, costs of marketing, slaughter, and management were not included.

Graded carcass prices, based on ''Yellow Sheet'' prices, did not cover estimated costs of production for any treatment. Differences between graded carcass prices and estimated costs of production ranged from –10 cents to –34 cents per pound.

Costs per pound of retail beef were estimated by adjusting the estimated production costs to account for differences in retail yield and adding a 25 percent retail markup. Estimated costs per pound of retail cuts, determined in this manner, were $1.16 and $1.37 for forage-produced beef in Phases I and II, respectively. Phase I and Phase II costs for grain-on-forage beef were $1.22 and $1.47, respectively, and costs for 70-day feedlot beef were $1.35 and $1.51, respectively. The beef was marketed in three retail supermarkets at prices that did not cover these costs, except for the forage-produced beef in Phase I. This was not unexpected, given the level of beef prices that existed during the study.

Conclusions and Implications

Some of the more meaningful conclusions and/or implications that can be drawn from the results of this study include:

1. Feeding programs that call for a shift from a grain-on-forage ration to forage alone prior to slaughter fail to maximize benefits from the grain consumed. Desirable carcass characteristics and organoleptic quality are not maximized when grain is fed during an intermediate period in the animal's development cycle instead of during the finishing period prior to slaughter.
2. The 70-day feedlot finishing period was superior to the grain-on-forage program in that less total grain was consumed, carcass characteristics were equal or superior to those obtained with grain on forage, and less total labor was required.
3. Only minor differences in yellow fat color separated the forage-finished and grain-on-forage-finished carcasses. Complete removal from

forages is required to eliminate yellow pigment from the fat.

4. This study found no evidence of discrimination by consumers against forage-finished cattle on the basis of a darker lean and more yellow fat. This should be of interest to marketmen.

5. Costs of producing consumer-acceptable beef on forages alone are not necessarily lower than costs of producing beef with grain. Producers finishing cattle for slaughter on forages should shift to a grain-finishing treatment whenever forage deterioration and/or declining grain prices make the shift economically beneficial.

6. LSU beef was marketed during a period of depressed beef prices. Therefore, there was less incentive for retail customers to seek out bargain priced beef of unknown quality than there would have been if beef prices had been higher. Nevertheless, the LSU beef sold readily, indicating customers were impressed with the beef as well as the prices.

7. Purchasers of the LSU beef were unable to consistently distinguish differences due to feeding treatments. Numerical differences in average ratings among feeding treatments were small. Beef finished on forages, with grain on forages, and with 70 days in feedlot all received favorable ratings from purchasers.

8. Household panels were able to distinguished some differences in the LSU beef due to feeding treatment. However, average ratings by household panels were numerically close for all treatments. Average ratings by feeding treatment for tenderness, flavor, juiciness, and overall acceptability were favorable. Household panel members indicated by their ratings that beef from forage-finished and grain-on-forage-finished steers compared favorably with beef from steers finished for 70 days in feedlot.

9. Socioeconomic data (age, education, and income) on prospective consumers should be seriously considered in evaluating the potential market for forage-finished beef in any locality.

10. Household panel ratings of the LSU beef for tenderness, juiciness, flavor, and overall acceptability did not differ significantly by estimated quality grade. Household panel "write-in" prices for the beef they had consumed did not differ significantly by estimated quality grade, except for round steaks. These results indicate that quality grade should not be an important factor in pricing forage-finished and limited-grain-finished beef.

11. Trained laboratory taste panels were able to distinguish some real differences in organoleptic quality of beef from different feeding treatments. Panel members gave higher numerical ratings to beef finished in the feedlot. However, with the exception of Phase II, average ratings for tenderness, flavor, juiciness, and overall acceptability were all in the favorable end of the rating scale for the forage-finished beef.

12. None of the means of evaluation used in this study was able to effectively distinguish between forage-finished beef and beef finished with limited grain when carcass weights exceeded 500 pounds. Therefore,

forage-finished beef should be marketed at carcass weights greater than 500 pounds.

13. The high acceptability ratings given the 70-day feedlot beef by all means of evaluation indicate beef does not have to be finished for lengthy periods in feedlots to be fully acceptable to most beef consumers.

14. Results from retail sales, household panels, and laboratory panels suggest that a retail market exists for forage-finished beef. Capture and expansion of this market will require the complete support of all elements of the beef marketing system.

Very little beef possessing the characteristics of the beef evaluated in this study is available in retail food stores. Many chain supermarkets sold heavy calf or baby beef alongside USDA Choice beef during the liquidation phase of the recent production cycle. This beef was marketed at substantial price discounts from Choice grade beef. Animals producing this beef were fed grain for short periods and slaughtered at liveweights of 700 pounds or less. Therefore, the beef came from younger and lighter animals than those producing the beef evaluated in this study. Many supermarket chains handled heavy calf only because it was more readily available than heavy, feedlot-finished beef.

It is generally recognized that many retailers, wholesalers, and meat packers are biased against beef from cattle not finished in feedlot. This bias may result from a preconceived notion of a positive relationship between length of feedlot finishing and the quality attributes tested in this study. However, this notion may be in error, at least with respect to many potential consumers. Acceptability ratings given the mature, heavy forage-finished and limited-grain-finished beef evaluated by consumers in this study justify a re-evaluation by the beef industry of the market for this type beef. Consumers cannot purchase or evaluate products that are not available in the food stores they normally patronize.

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Appendix

Appendix Table 1.—Grain ration composition,[1] LSU Beef Marketing Study, Phases I - II

Ingredient	Pounds/ton
Ground yellow corn	1,340
Cottonseed hulls	300
Cottonseed meal	200
Urea	20
Calcium carbonate	20
Salt	20
Molasses	100
Total	2,000

[1] Grain-on-forage steers received a ration composed of 1,970 pounds of ground yellow corn and 30 pounds of urea.

Appendix Table 2.—Analysis of variance of treatment and store effects and their interactions, retail purchasers, LSU Beef Marketing Study, Phases I - II

		Level of significance							
		Tenderness		Flavor		Juiciness		Overall	
Source	D.F.	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II
Treatment	—[1]	.292	.032	.038	.033	.017	.075	.084	.146
Store	2	.537	.033	.614	.131	.206	.169	.619	.033
Treatment-store	—[1]	.518	.501	.144	.649	.065	.589	.132	.718

[1] Degrees of freedom were 4 (Treatment) and 8 (Treatment-store) for Phase I, and 3 (Treatment) and 6 (Treatment-store) for Phase II.

Appendix Table 3.—Selected characteristics of household consumer panels, LSU Beef Marketing Study, Phases I - III

Age of homemaker		Education of homemaker		Annual family income	
Years	%	Level	%	Dollars	%
		Phase I			
Less than 30	28.7	Elementary	—[1]	Less than 5,000	5.3
30-39	20.7	High school	52.7	5,000-9,999	18.7
40-49	25.3	College	33.3	10,000-20,000	60.7
50-59	19.3	College grads	14.0	More than 20,000	15.3
60-65	6.0				
More than 65	—[1]				
		Phase II			
Less than 30	26.0	Elementary	0.7	Less than 10,000	21.2
30-39	22.7	High school	48.4	10,000-19,999	49.8
40-49	19.8	College	24.5	20,000-29,999	21.3
50-59	20.9	College grad	26.4	30,000-50,000	6.6
More than 60	10.6			More than 50,000	1.1
		Phase III			
Less than 30	22.0	Elementary	10.7	Less than 10,000	15.5
30-39	29.2	High school	31.0	10,000-19,999	35.0
40-49	20.8	College[2]	45.8	20,000-29,999	29.2
50-59	19.0	Other[3]	12.5	30,000-50,000	17.3
60-65	4.2			More than 50,000	3.0
More than 65	4.8				

[1] Households were considered ineligible for participation if the homemaker was more than 65 years old or had less than 8 years of formal education.

[2] Includes college graduates.

[3] Includes business school, nursing, vocational-technical school, etc.

Appendix Table 4.—Analysis of variance of treatment effects within phases, household panel, LSU Beef Marketing Study, Phases I - III

		Level of significance			
Phase	D.F.	Tenderness	Flavor	Juiciness	Overall
I	4	.014	.777	—[1]	.802
II	3	.001	.027	.015	.082
III	3	.936	.185	.321	.392

[1] Not evaluated.

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NUTRITIONAL and AGRONOMIC COMPARISONS of FOUR WARM-SEASON PERENNIAL GRASSES

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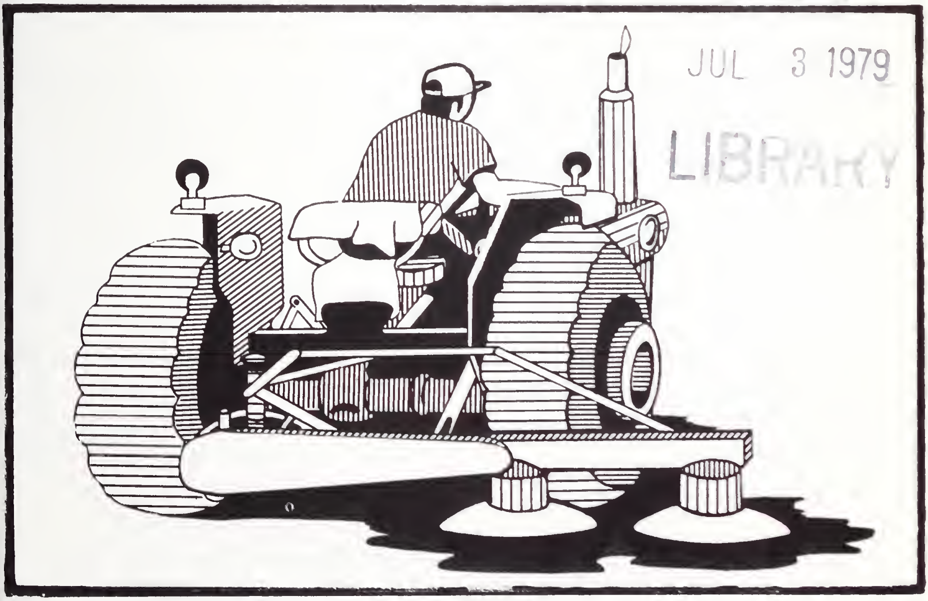

LOUISIANA STATE UNIVERSITY
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Center for Agricultural Sciences
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AGRICULTURAL EXPERIMENT STATION
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Nutritional and Agronomic Comparisons of Four Warm-Season Perennial Grasses

CHARLES R. MONTGOMERY,[1] MARVIN ALLEN,[2]
J. G. KOWALCZUK,[3] P. E. SCHILLING,[4] AND L. F. MASON[5]

Introduction and Objectives

Summer-growing perennial grasses play an important role as sources of grazing and harvested hay in feeding programs of Louisiana's livestock industry. Pasture typically furnishes approximately 50 percent of the feed for dairy cattle in the southern states as compared to 25 percent in the more heavily populated north Atlantic states. Hodgson (*7*)[6] reported data that showed the cost of producing 100 pounds of total digestible nutrients (TDN) from pasture was approximately one-third that of producing an equal amount of TDN from grain. With the increasing demand for grain for human consumption, more emphasis is being placed on forage production, quality, and utilization by ruminants.

Since warm-season perennial grasses vary considerably in nutritive value at different periods of the year, their evaluation throughout the entire growing season is important. Considerable information has been obtained on the quality and yield of most of these summer grasses, but few attempts have been made to evaluate them under similar conditions.

An experiment was conducted with four warm-season perennial grasses grown under identical environmental and management conditions with the following objectives:

(1) To characterize forage yield and yield distribution throughout the growing season.
(2) To determine relative quality among forages throughout the growing season.

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[6] Italic numbers in parentheses refer to Literature Cited, page 27.

Review of Literature

Data available on the grasses used in this study indicate that all are well adapted as permanent pasture crops in Louisiana.

'Pensacola bahiagrass' was first introduced into the United States in 1913. Ward and Watson *(13)* summarized some of the more important aspects of bahiagrass as a forage crop. Bahiagrass is popular in the South because: (a) it tolerates a wide range of soil conditions, (b) it is resistant to encroachment of weeds, (c) stand establishment is by seeding, (d) it is relatively free from attack by insects and disease organisms, (e) it produces moderate yields on soils of low fertility, and (f) it withstands close grazing. The authors also stated that beef gains on bahiagrass were intermediate to gains on common and 'Coastal' bermudagrasses. Forage quality of bahiagrass was highest in early spring, but by mid-summer the percentage of cell wall constituents (CWC) was sufficiently high to suggest that animal intake would be limited. Dry forage yields of 15,000 pounds per acre have been reported when harvested at 4-week intervals *(8)*.

Coastal bermudagrass, another grass used in this study, was released in 1938 and is characterized by larger and longer leaves, stems, and rhizomes than common bermudagrass *(4)*. Coastal produces only a few seed heads, and they rarely contain viable seed. It is estimated that some 5 million acres of Coastal are grown in the South, and dry forage yields of 17,500 pounds per acre have been reported *(1)*.

Duble et al. *(6)* compared Coastal, common, and 'Coastcross-1' bermudagrasses and Pensacola bahiagrass harvested at 14-day intervals from April 23 through July 16. The highest quality, as measured by CWC content, was found in Coastcross-1 bermudagrass, followed by forages of common bermudagrass, Coastal bermudagrass, and Pensacola bahiagrass, with seasonal average CWC values of 58.6, 59.3, 62.4, and 64.7 percent, respectively. In vitro digestible dry matter (IVDDM) data also ranked Coastcross-1 bermudagrass forage highest and Pensacola bahiagrass lowest, with IVDDM values of 77.2 and 61.8 percent, respectively.

Chapman et al. *(5)* reported that steers grazing Coastcross-1 bermudagrass had higher average daily gains (ADG) than did steers on Coastal bermudagrass and Pensacola bahiagrass pastures. It was noted that dry matter yields of Coastal bermudagrass tended to be higher than yields of Coastcross-1 bermudagrass and Pensacola bahiagrass.

'Alicia' is a more recent release among hybrid bermudagrasses on which only limited forage quality measurements have been made. It and three other bermudagrass cultivars were harvested at 35-day intervals with seasonal average acid detergent fiber (ADF) values as follows: Common, 32.3; Coastal, 34.2; Alicia, 34.9; and Coastcross-1, 37.3 percent *(9)*.

Allen *(1)* reported highest total dry matter yields with Alicia bermudagrass, followed by Coastal, Coastcross-1, common, and Pensacola bahiagrass when harvested at 4-week intervals. He observed a more uniform yield distribution with Pensacola bahiagrass and concluded that Pensacola could be better utilized as a grazing crop rather than a hay crop. Alicia had the highest structural carbohydrate percentages, while Pensacola and Coastcross-1 had the highest IVDDM values.

Experimental Procedure

Agronomic Procedure

Four warm-season perennial grasses were established on adjacent half-acre plots on a Providence silt loam soil during late summer of 1973. Included were three genotypes of bermudagrass — Coastal, common, and Alicia — and Pensacola bahiagrass. Agronomic and qualitative evaluations were initiated in the spring of 1974. Each plot was fertilized in late March with 75-200-300 pounds per acre of N, P_2O_5, and K_2O, respectively, followed by 75 pounds of N per acre after each harvest.

All grasses were pre-clipped to a stubble height of 3 inches in early April to provide a uniform starting date for harvesting. The grasses were harvested at 28-day intervals throughout the growing season.

Yield data were obtained by cutting five random strips, 5 by 12 feet, in each of the half-acre plots. The remaining forage on each of the half-acre plots was harvested and artificially dried in a forced-air, thermostatically controlled drier at 130°F. The dried forage was then chopped with a hammer mill to approximately half-inch lengths. This chopping was needed to reduce animal selectivity during the feeding trials and to aid in weighing.

In Vivo Digestibility Trials

Each of the chopped forages was fed to four sheep, which served as replicates, in conventional digestion trials consisting of a 9-day preliminary period, a 5-day total-fecal-collection period, and a 7-day voluntary intake period. The sheep were maintained in conventional digestion crates that permitted individual feeding (twice daily), weigh-backs (once daily), and total fecal collection. The chopped forages were sampled during each digestion trial, dried, and ground in a Wiley Mill to a 1-millimeter fineness for laboratory analyses.

Forage Quality Measurements

Cell wall constituents (CWC), acid detergent fiber (ADF), hemicellulose, cellulose, acid-insoluble lignin (AIL), and in vitro digestible dry matter (IVDDM) were determined by the Van Soest procedure *(12)*. The IVDDM procedure was modified by the addition of glucose and urea to the buffer solution *(10)*. Determinations of crude protein (CP), calcium (Ca), phosphorus (P), potassium (K), magnesium (Mg), and sulphur (S) content in the forages were made according to A.O.A.C. procedures *(3)*.

Statistical Analyses

Statistical analyses of the data were conducted according to procedures described by Snedecor and Cochran *(11)*. The data on replications, clipping dates, and years were analyzed. Data are reported graphically as clipping-date means. A stepwise regression analysis of each variable on each clipping date was conducted using the linear, quadratic, cubic, and quartic terms for clipping dates. Regression analyses were based on data collected over a 2-year period (1974-1975).

Results and Discussion

Dry Forage Yield Per Acre

Season-total dry forage yields, in pounds per acre, for the grasses were: Alicia—17,951; Coastal—16,162; common—15,868; and Pensacola-13,582. Dry forage yields among bermudagrass varieties were not significantly different throughout the growing season (Figure 1). The bermudagrasses produced higher yields than Pensacola early in the growing season (May-July). Alicia produced more forage than Pensacola from May through September, except at the August 20 harvest. Coastal and common yields were highest on the May harvest date, and their yields decreased continuously as the season advanced. All forage yields decreased as season advanced after May 28, although the yield of Pensacola was rather stable from May 28 through August 20.

These data indicated that Pensacola was less tolerant of cool spring nights and was slower in initiating new growth than the bermudagrasses. In early May, the bermudagrasses produced approximately two-and-one-half times as much dry forage as Pensacola did. In grazing systems, stocking rates would have to be adjusted over the season to effectively utilize forages produced by the grasses. An alternative would be to harvest the excess forage as hay when weather conditions permitted proper curing.

Structural Carbohydrates

Cell Wall Constituents. Cell wall constituents (CWC) include the total fibrous fraction of the forage. These fractions include acid detergent fiber (ADF) and hemicellulose. The ADF is further subdivided into cellulose and lignin. The fibrous portion of the plant is the material acted on by microflora in the rumen. The CWC makes up the major portion of the perennial plant cell, and generally, the higher the CWC in a forage the lower the quality of that forage.

The forage CWC percentages of the four grasses are shown in Figure 2. There was an almost linear increase in CWC percentage of Alicia as the season advanced. The CWC of common, Coastal, and Pensacola was not significantly affected by date of harvest, and therefore, the seasonal mean values of 71.1, 71.5, and 72.3 percent, respectively, are shown rather than a regression line. Alicia exhibited consistently higher CWC percentages than the other grasses. This difference was significant ($P<.05$) after July 23.

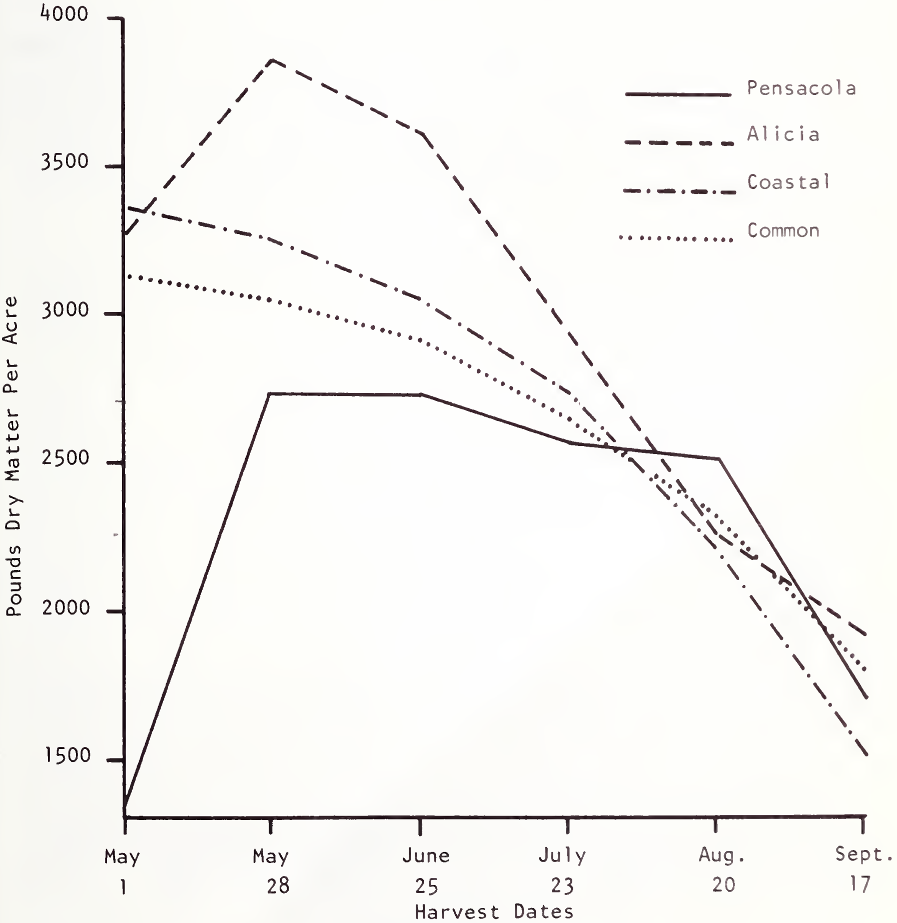

Figure 1.—Seasonal distribution of dry forage yield of four perennial grasses, 1974-75.

Acid Detergent Fiber. Acid detergent fiber (ADF) is a more realistic measure of the forage fiber that may be digested by a ruminant than is crude fiber, since ADF includes lignin which is only partially extracted in the crude fiber analysis. Pensacola exhibited higher ADF percentages than the other forages after May 28, as shown in Figure 3. The high ADF content found in Pensacola during July and August, followed by a lower value in September, is in agreement with the findings of other researchers *(2)*. This high ADF content was probably due to the presence of a greater proportion of stems and seed heads in the forage during the mid-summer months when the plants enter the reproductive stage. In late summer, Pensacola typically reverts primarily to vegetative growth, with fewer seed heads being formed. Such morphological changes could help account for the lower ADF percentages found during the latter part of the growing season. The ADF percentages of Alicia, Coastal, and common were not significantly affected by date of harvest, so seasonal means, rather than regression lines, are shown for them in Figure 3. Alicia had a seasonal mean ADF percentage of 36.0, which was significantly higher than those of Coastal and common, with seasonal means of 33.6 and 31.6 percent, respectively.

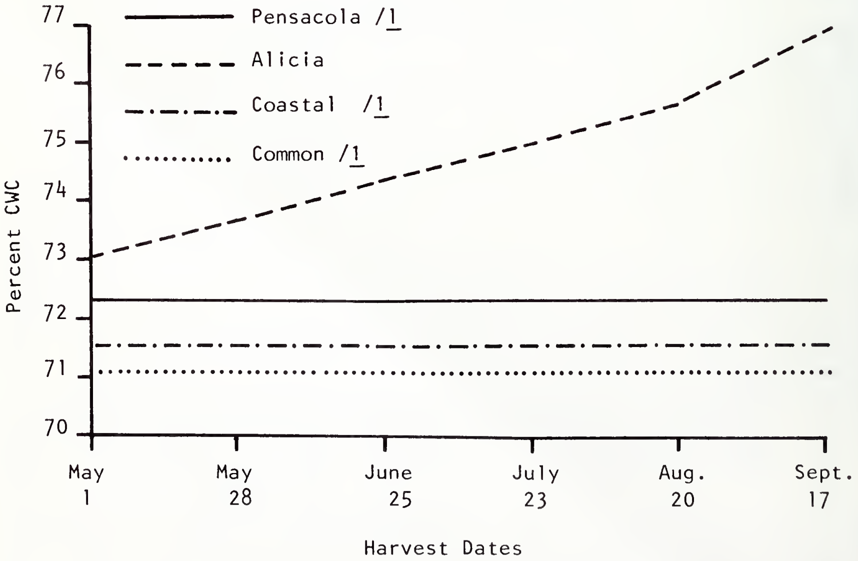

Figure 2.—Cell wall constituent content of four perennial grasses, 1974-75.

[1] Horizontal line indicates seasonal means were not significantly affected by harvest date.

Hemicellulose. Hemicellulose content in forage is regarded as the difference between CWC and ADF and is generally more digestible than cellulose. It is composed of a mixture of polymers which may have different digestion coefficients within the same forage. Pensacola was consistently lower in hemicellulose than the other grasses, as shown in Figure 4. The hemicellulose percentages of Pensacola decreased from May until July and then increased through September. Hemicellulose percentages of Alicia increased linearly as the season advanced. Common and Coastal hemicellulose contents were not significantly affected by date of harvest, with seasonal means of 39.5 and 38.1 percent, respectively. All of the bermudagrasses were significantly higher in hemicellulose than Pensacola, with the exception of the first and last harvests.

Cellulose. Significant differences were noted in cellulose percentages among the four grasses (Figure 5). Pensacola consistently produced the highest cellulose content, while common produced the lowest. Alicia was

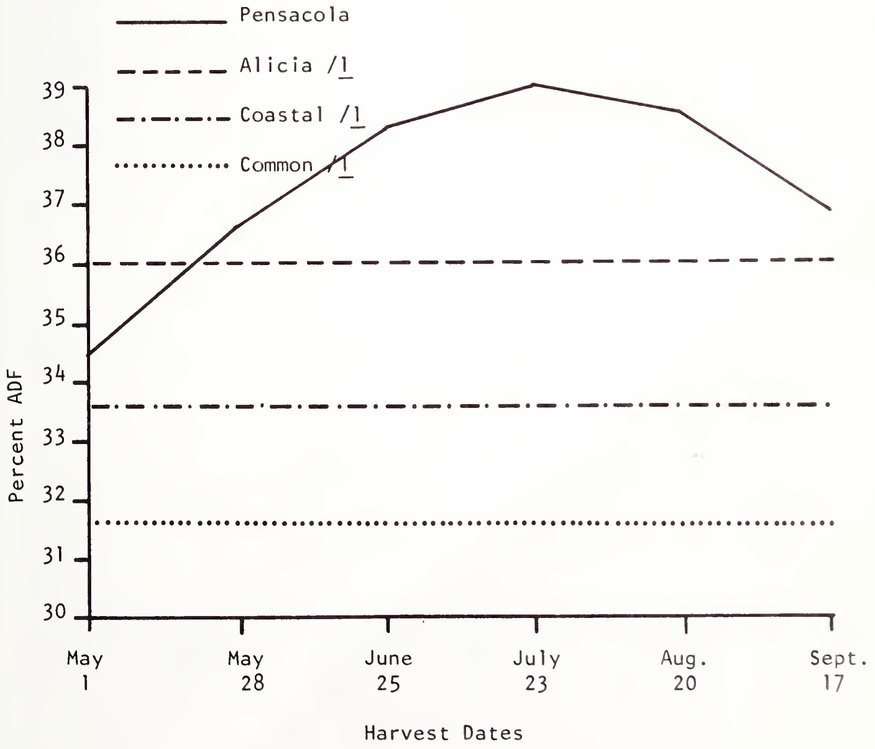

Figure 3.—Acid detergent fiber content of four perennial grasses, 1974-75.

[1] Horizontal line indicates seasonal means were not significantly affected by harvest date.

significantly higher in cellulose than common at all harvest dates, and higher than Coastal at all harvests except the first. Coastal and common cellulose percentages were not significantly different at any harvest date, but common consistently had the lowest numerical value. Cellulose content of Coastal was not significantly affected by date of harvest, with a seasonal mean of 27.6 percent.

Acid-Insoluble Lignin. Lignin is considered to be completely indigestible and is a true anti-quality factor. Acid-insoluble lignin (AIL) content in Pensacola increased linearly, from 3.26 percent on May 1 to 5.28 percent on September 17, as shown in Figure 6. The only significant difference noted among AIL percentages of the grasses after June 25 was between common and Pensacola on September 17. The bermudagrasses did, however, have significantly higher AIL percentages than Pensacola during the first two harvests. The AIL content of Alicia and Coastal was not significantly affected by harvest date, and seasonal means of 4.70 and 4.53 percent, respectively, were observed.

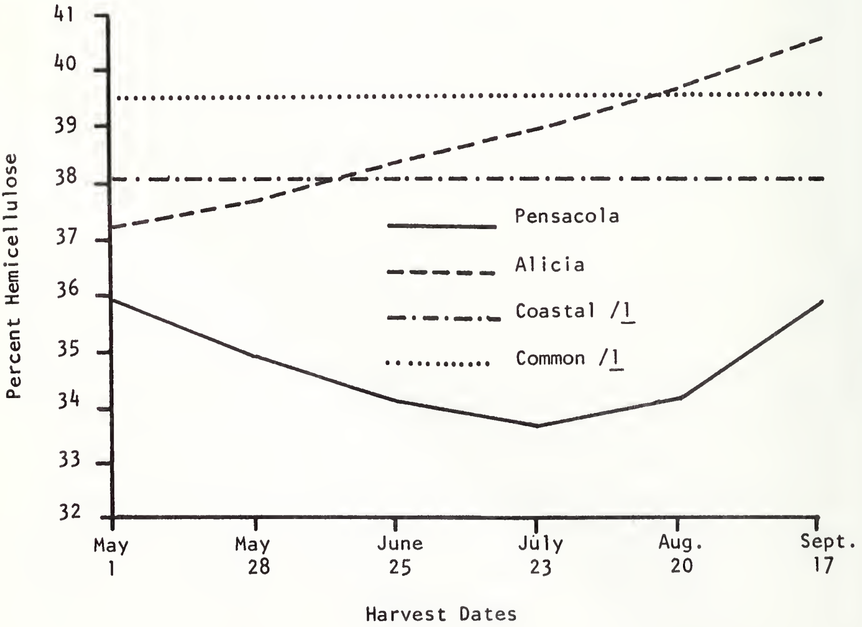

Figure 4.—Hemicellulose content of four perennial grasses, 1974-75.

[1] Horizontal line indicates seasonal means were not significantly affected by harvest date.

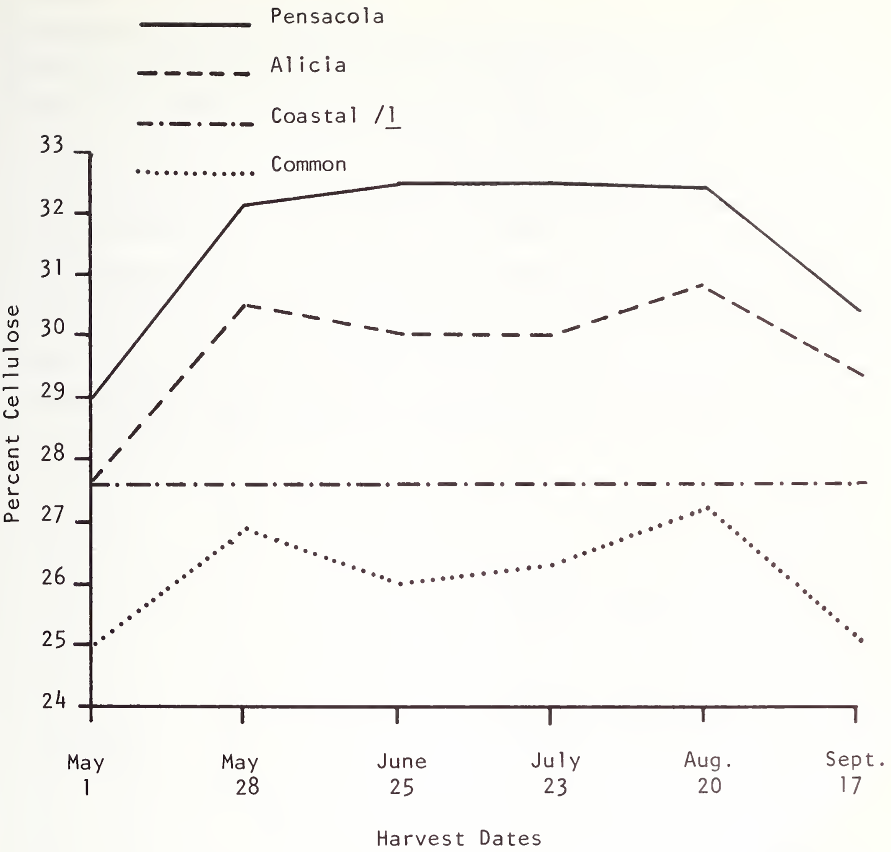

Figure 5.—Cellulose content of four perennial grasses, 1974-75.

[1] Horizontal line indicates seasonal means were not significantly affected by harvest date.

Crude Protein

The crude protein (CP) content of forages has long been recognized as an indicator of forage quality for ruminants. A level of forage CP ranging from 15.6 to 18.7 percent on a dry matter basis is considered adequate to meet the protein needs of a beef cow with calf.

As noted in Figure 7, these perennial grasses met the minimal protein requirements only in early May and in September during the 2-year study. A sharp decrease in CP occurred in all grasses after May 1 with only slight changes during the mid-summer months. However, the CP content of all forages increased dramatically in September. There were no significant differences in CP percentage among grasses at any harvest date. Alicia had numerically lower protein values during the first half of the season, while common harvested in June and July had numerically higher CP percentages than those of other grasses, but neither was statistically significant.

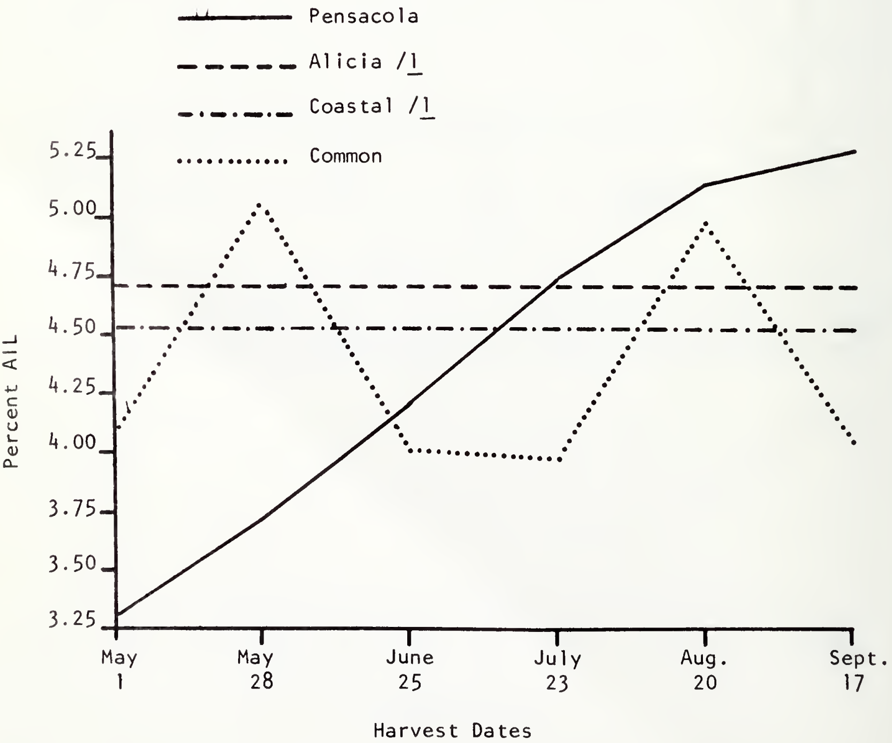

Figure 6.—Insoluble lignin content of four perennial grasses, 1974-75.

[1]Horizontal line indicates seasonal means were not significantly affected by harvest date.

Minerals

Calcium. Calcium (Ca) is recognized as an essential secondary nutrient for plant growth, and also as an essential and major mineral in animal nutrition. A range in Ca content of 0.22 to 0.25 percent in forage is considered adequate for beef cows. The Ca content in all forages tested was above 0.30 percent throughout the entire season (Figure 8). The Ca level in Pensacola decreased from 0.40 percent on May 1 to 0.31 percent in June and July and then increased to 0.42 percent in September. Ca content of the bermudagrass forages was not significantly affected by harvest date, with seasonal means ranging from 0.43 for Coastal to 0.48 percent with Alicia.

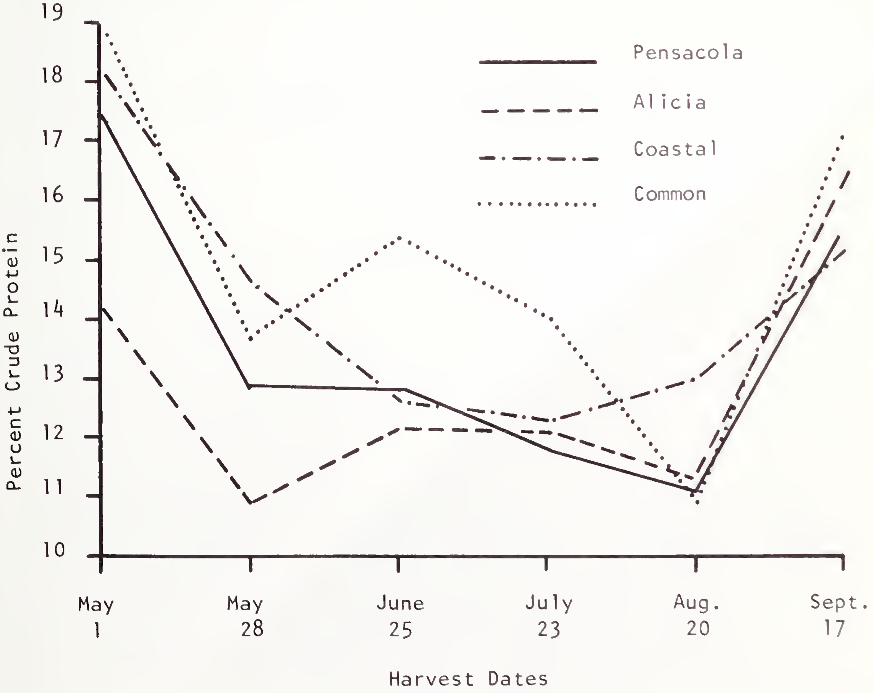

Figure 7.—Crude protein content of four perennial grasses, 1974-75.

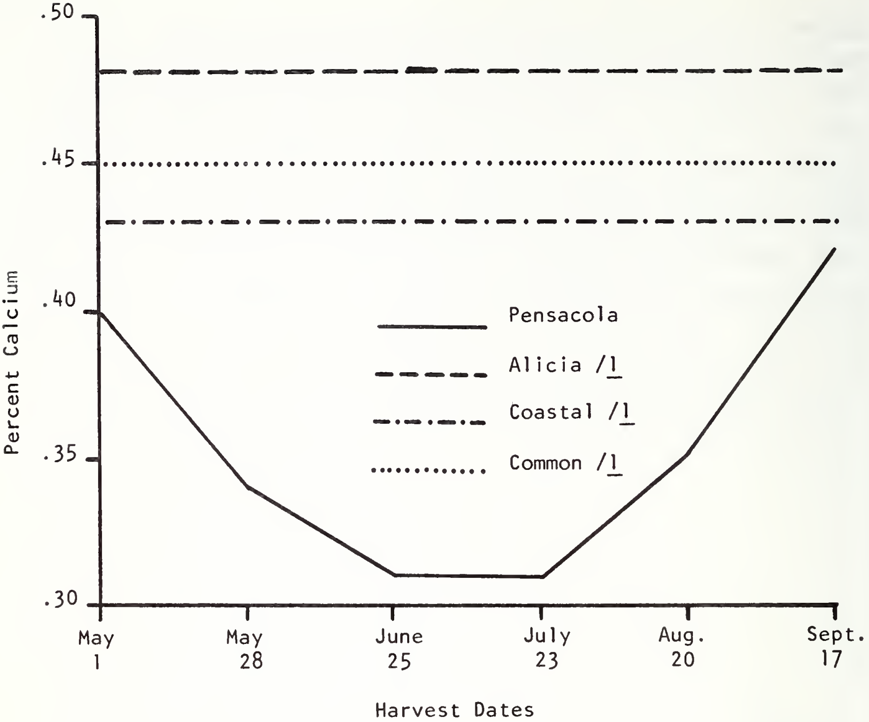

Figure 8.—Calcium content of four perennial grasses, 1974-75.

[1] Horizontal line indicates seasonal means were not significantly affected by harvest date.

Phosphorus. All of the grasses, with the exception of Pensacola harvested in June and July, were at or above the minimum level of 0.26 percent phosphorus (P) considered necessary for maintenance of ruminants on an all-forage diet (Figure 9). Phosphorus content of Pensacola decreased during May and June, followed by a gradual increase through September. The P content of bermudagrasses was not significantly affected by date of harvest. While Alicia was highest in P throughout most of the growing season, there were no significant differences noted in P content among any of the grasses.

Potassium. There was a strong trend toward lower potassium (K) content of all grasses with advances in the season (Figure 10). Pensacola exhibited a lower K percentage than the bermudagrasses at all except the September harvest. There were, however, no significant differences noted among K content of forage of any of the grasses at any one harvest date.

It has been suggested by the National Research Council that a forage K level of 1.2 percent would be considered minimal for proper ruminant nutrition when the forage served as the total diet. The K content of all four

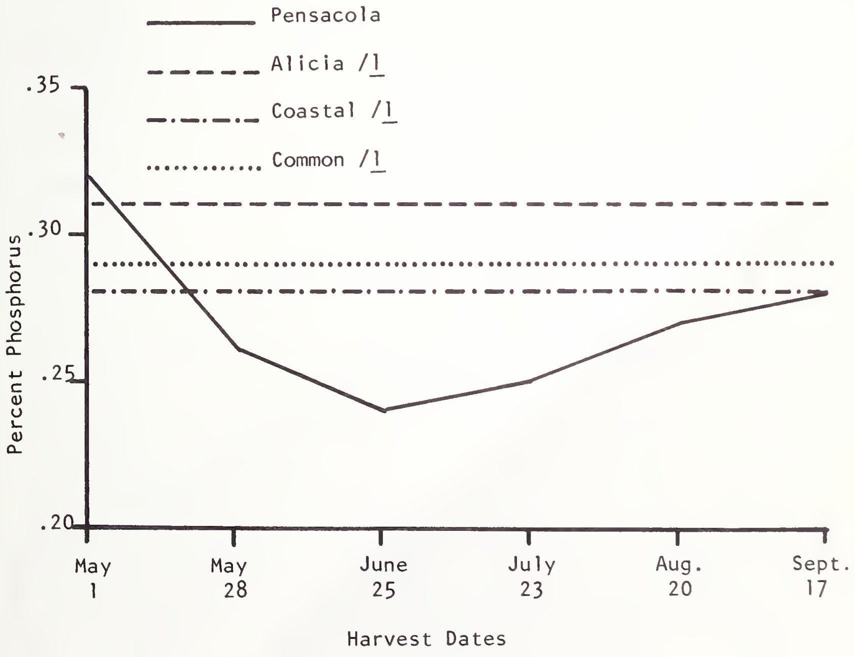

Figure 9.—Phosphorus content of four perennial grasses, 1974-75.

[1] Horizontal line indicates seasonal means were not significantly affected by harvest date.

grasses met the minimum requirements for maintenance of ruminants throughout the season, even at the September harvest.

Magnesium. The minimum maintenance level of 0.16 percent magnesium (Mg) for ruminants was exceeded in all the grasses, with the exception of Coastal harvested during the first half of the growing season (Figure 11). The Mg percentages of both Coastal and Pensacola increased as the season advanced. Pensacola exhibited consistently higher forage Mg levels through the season than the other grasses. The Mg content of common and Alicia forages was not significantly affected by harvest date, with seasonal averages of 0.18 and 0.16 percent, respectively.

Sulfur. The sulfur (S) content of bermudagrasses was higher than that of Pensacola forage, as noted in Figure 12. There was a linear decrease in S

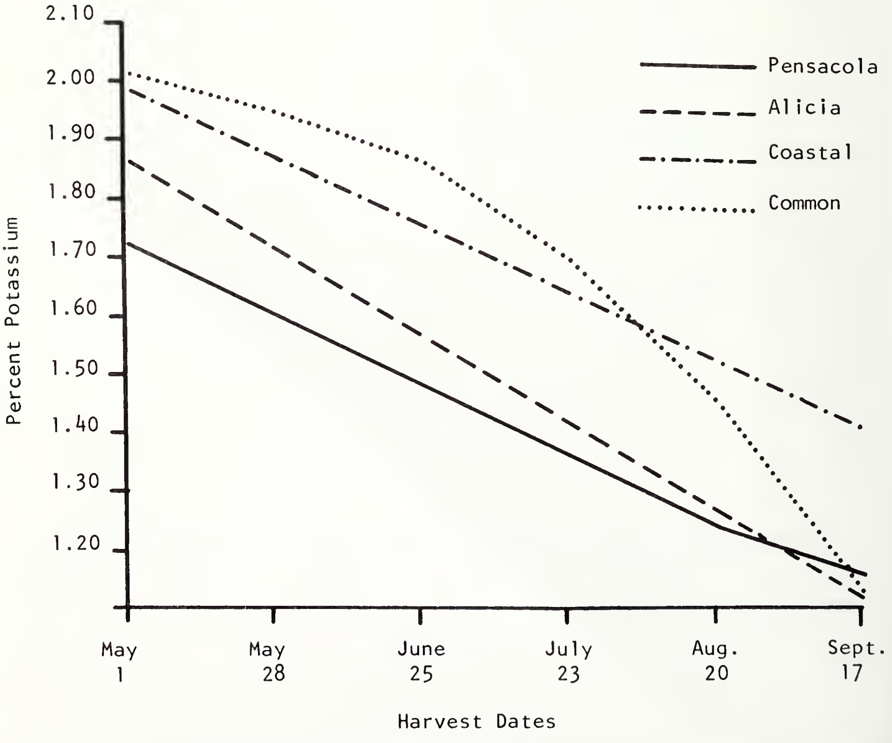

Figure 10.—Potassium content of four perennial grasses, 1974-75.

content of common forage throughout the season. Sulfur percentage of Alicia forage decreased from 0.38 on May 1 to 0.23 on July 23 and then increased to 0.31 percent in September. Sulfur content in Coastal was not significantly affected by harvest date, with a seasonal average of 0.22 percent.

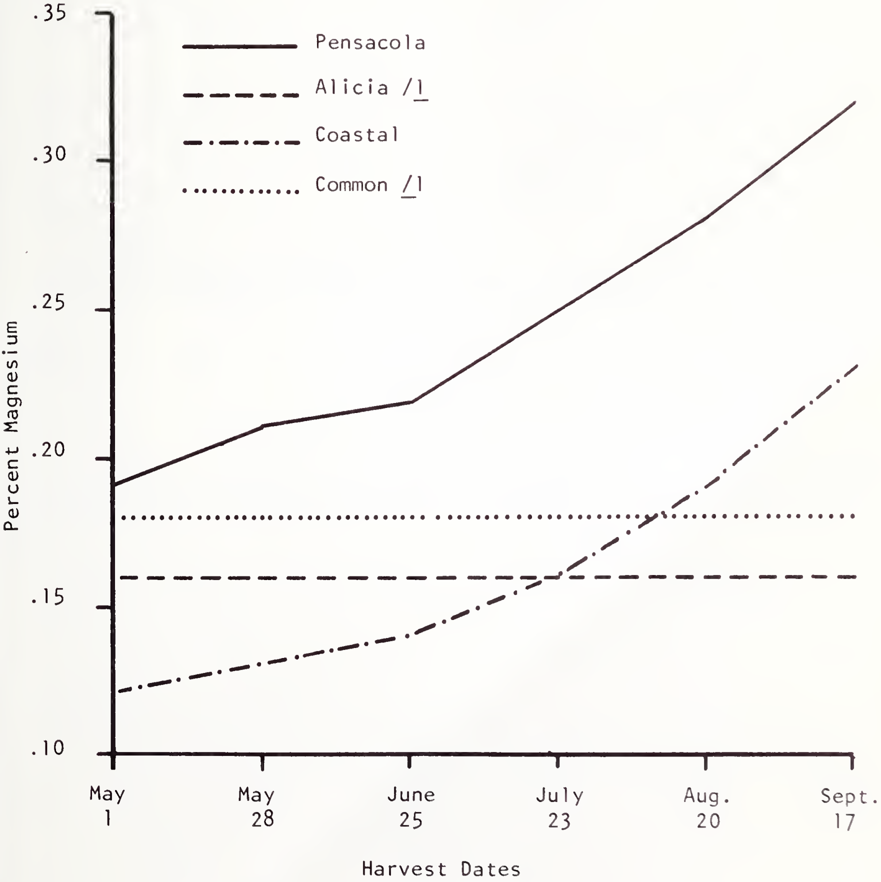

Figure 11.—Magnesium content of four perennial grasses, 1974-75.

[1] Horizontal line indicates seasonal means were not significantly affected by harvest date.

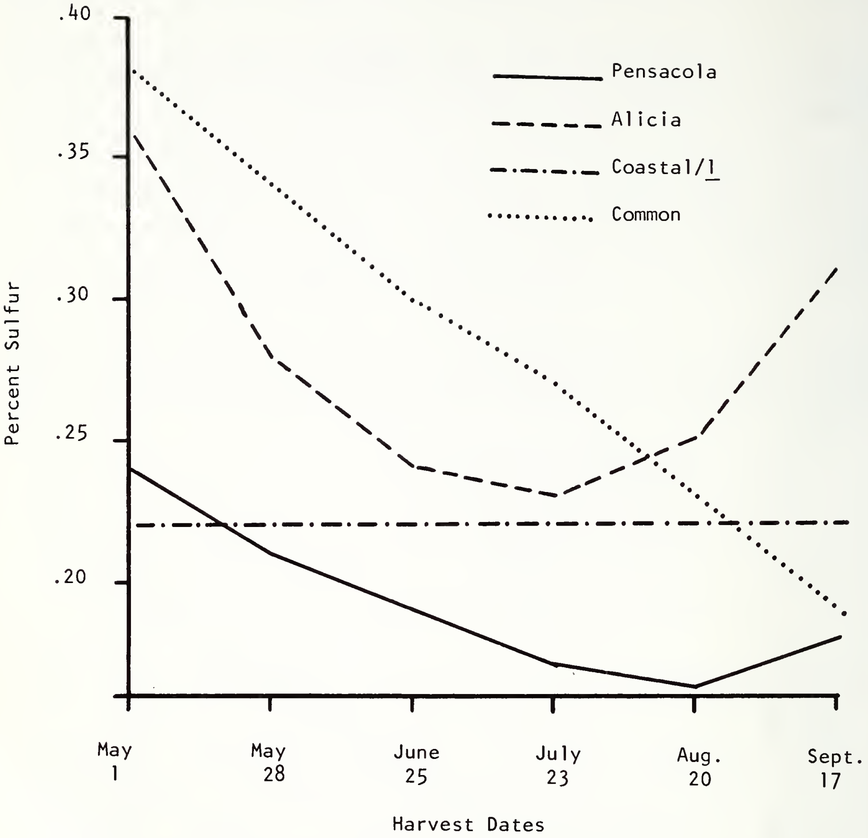

Figure 12.—Sulfur content of four perennial grasses, 1974-75.

[1] Horizontal line indicates seasonal means were not significantly affected by harvest date.

Digestion Coefficients

In Vivo Digestible Dry Matter. Forage digestibility is closely related to animal performance (beef and milk production), which is the ultimate forage quality evaluation. In vivo digestible dry matter (DDM) values show that Pensacola was the most digestible of the grasses early in the growing season (Figure 13). Pensacola DDM dropped from 63.0 percent on May 1 to about 56.0 percent in August and September. Throughout the season Pensacola forage was more digestible than that of Alicia bermudagrass. At the first harvest, Alicia was 58.5 percent digestible. However, digestibility declined to a low of 53.5 percent on June 25, after which it increased until August 20 and then dropped again. The DDM percentages of common and Coastal were not significantly affected by harvest date, with seasonal averages of 58.6 and 57.2 percent, respectively.

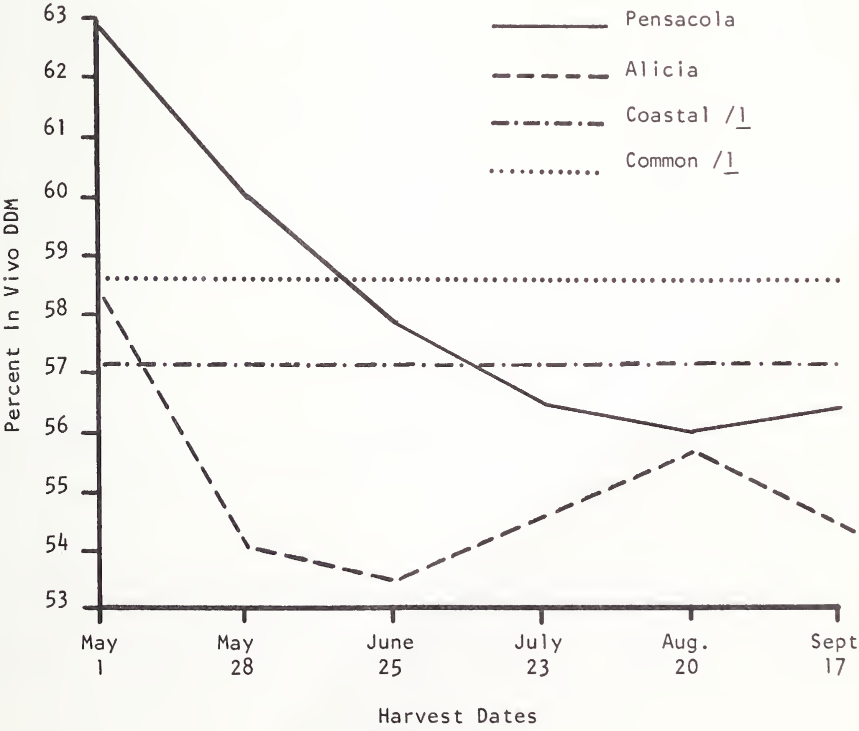

Figure 13.—In vivo digestible dry matter content of four perennial grasses, 1974-75.
[1] Horizontal line indicates seasonal means were not significantly affected by harvest date.

In Vitro Digestible Dry Matter. In vitro digestible dry matter (IVDDM) is generally regarded as a relative or approximate measure of the nutritional value of a forage. Results reported in other studies have shown a high positive correlation between IVDDM (test tube) values and DDM (animal) values for forages.

The IVDDM values reported in Figure 14 represent apparent DDM and were calculated from the formula: apparent DDM=15.1+.5446X, where X is the test tube digestibility value (*10*). The IVDDM percentage of Pensacola followed a trend very similar to that of the animal DDM data. IVDDM percentages of Pensacola ranged from 62.4 on May 1 to 54.8 on August 20, with an increase to 56.0 on September 17.

There were highly significant positive correlations between DDM and IVDDM values for all grasses as follows: Alicia (r=.73), Coastal (r=.89), common (r=.90), and Pensacola (r=.77).

The IVDDM percentages of the bermudagrasses were not significantly

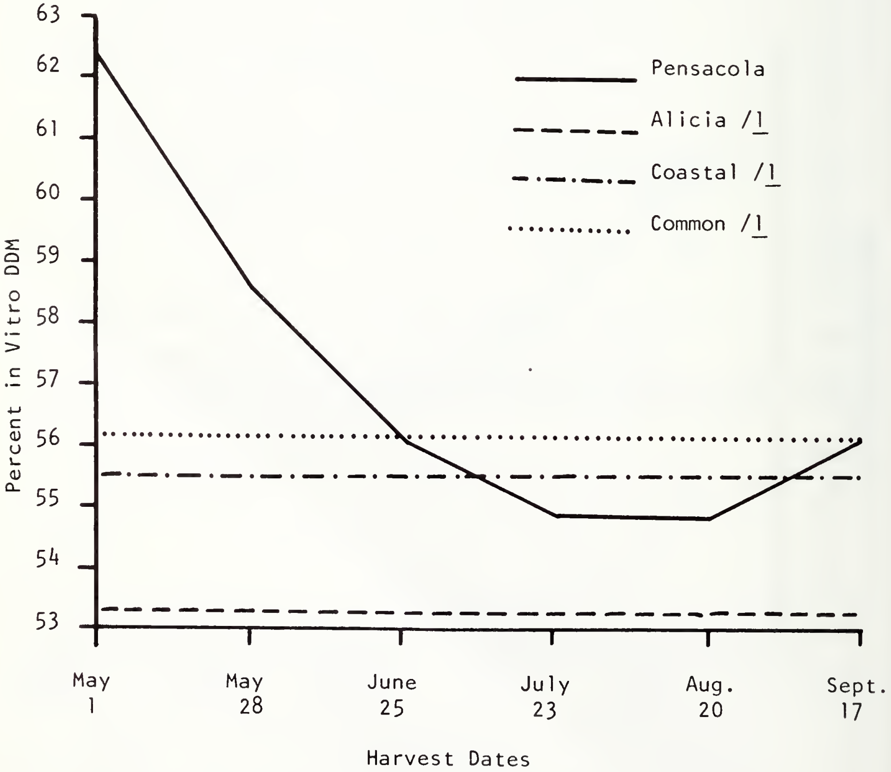

Figure 14.—In vitro digestible dry matter content of four perennial grasses, 1974-75.
[1] Horizontal line indicates seasonal means were not significantly affected by harvest date.

affected by harvest date. Season average IVDDM percentages of common and Coastal, 56.2 and 55.5, respectively, were not significantly different. Alicia had a significantly lower seasonal average IVDDM, 53.2 percent, than the other forages.

Animal Intake

Dry matter intake of a forage is directly related to palatibility, digestibility, and rate of passage. Dry matter intakes of the forages, expressed as percent of body weight of the sheep, are presented in Figure 15. No significant differences were noted in intake among the forages at any one harvest date. With the exception of Alicia, intake increased from May 1 through May 28 and then decreased during July and August. Intake of Coastal, common, and Pensacola increased slightly in September. There was no significant change in the intake level of Alicia due to season, with a seasonal average of 2.5 percent of body weight.

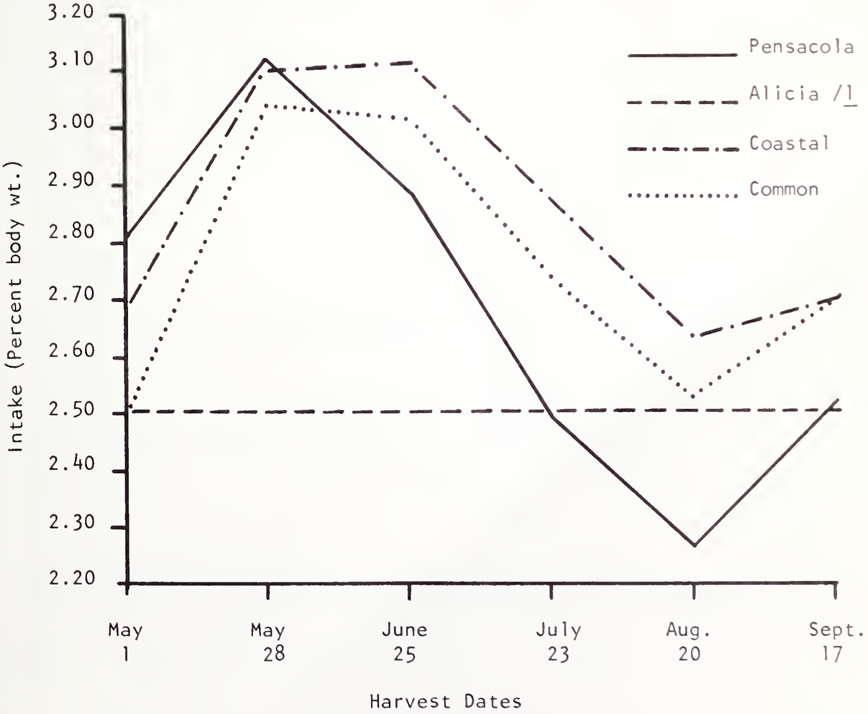

Figure 15.—Forage intake of four perennial grasses, 1974-75.

[1] Horizontal line indicates seasonal means were not significantly affected by harvest date.

Component Digestibility

Cell Wall Constituent Digestibility. All of the grasses exhibited their highest CWC digestion coefficients in forage of the first harvest and then decreased rapidly until May 28 (Figure 16). CWC digestion percentages were between 55 and 65 during the remainder of the season. Pensacola was highest in CWC digestibility throughout the season, with the exception of July 23, at which time common was slightly higher. Alicia had the lowest CWC digestion percentage until the September 17 harvest date.

Acid Detergent Fiber Digestibility. Pensacola was consistently higher in ADF digestibility than the bermudagrasses (Figure 17). There were no significant differences noted among the ADF digestion percentages in the bermudagrass forages at any harvest date. ADF digestion percentages of Pensacola, Alicia, and common decreased rapidly during May, with only

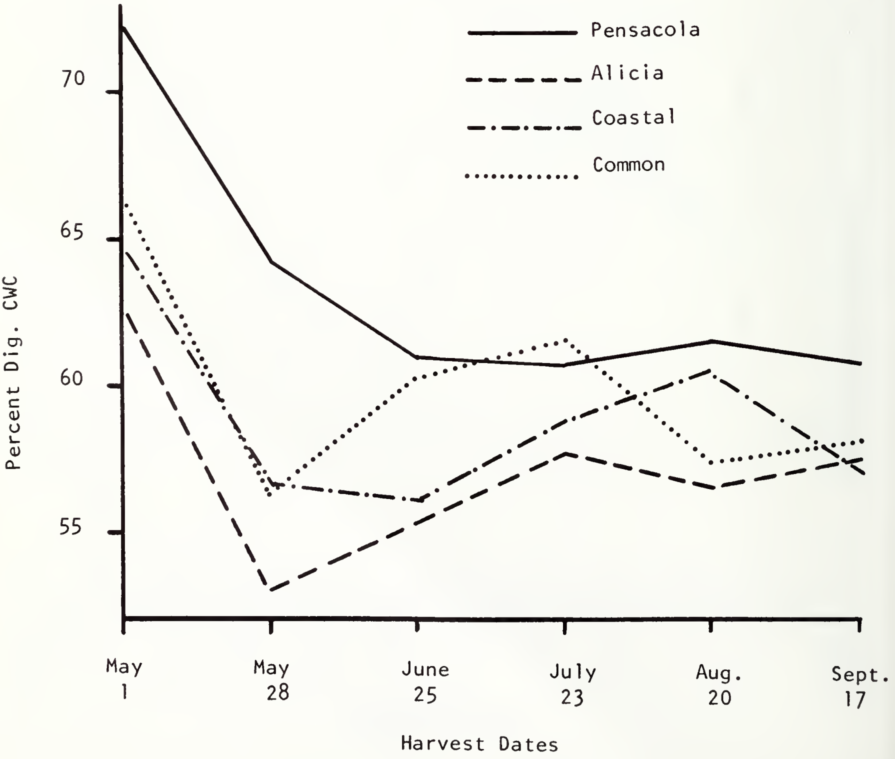

Figure 16.—Digestibility of forage cell wall constituents of four perennial grasses, 1974-75.

slight changes during the remainder of the season. The ADF digestion of Coastal was not significantly affected by harvest date, with a seasonal average of 52.0 percent.

Hemicellulose Digestibility. Hemicellulose digestibility of Pensacola was highest of all grasses at all dates (Figure 18). Alicia had the lowest hemicellulose digestibility until September, when Coastal exhibited a lower value.

Cellulose Digestibility. Cellulose digestibility followed trends very similar to those established with digestible CWC, ADF, and hemicellulose (Figure 19). Pensacola had the highest forage cellulose digestibility values throughout the growing season. The cellulose digestion percentages among bermudagrasses were not significantly different at any harvest date. Cellulose digestion of Coastal was not significantly affected by season and had a seasonal average of 62.5 percent.

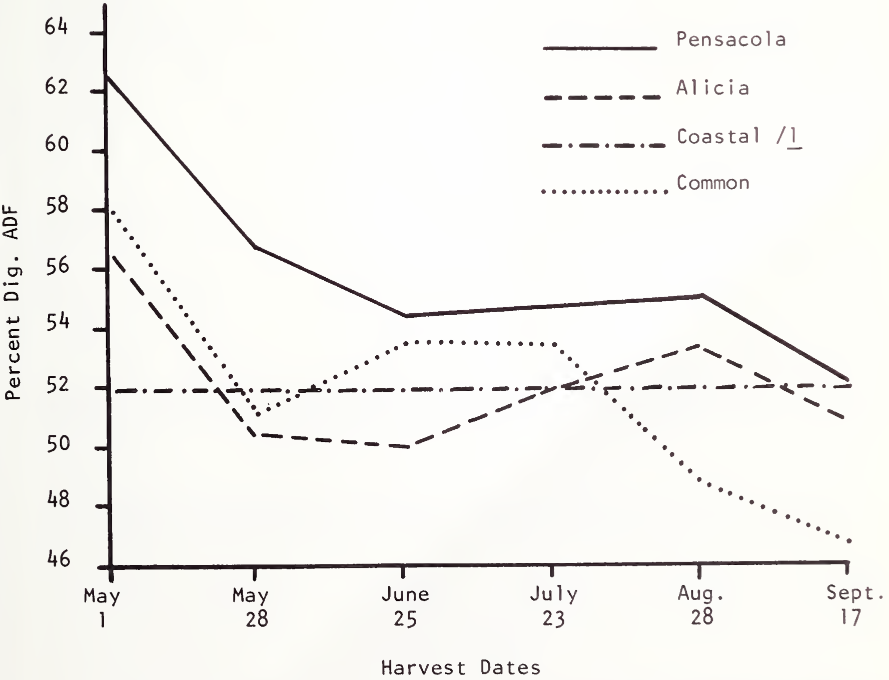

Figure 17.-Digestibility of forage acid detergent fiber of four perennial grasses, 1974-75.

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[1] Horizontal line indicates seasonal means were not significantly affected by harvest date.

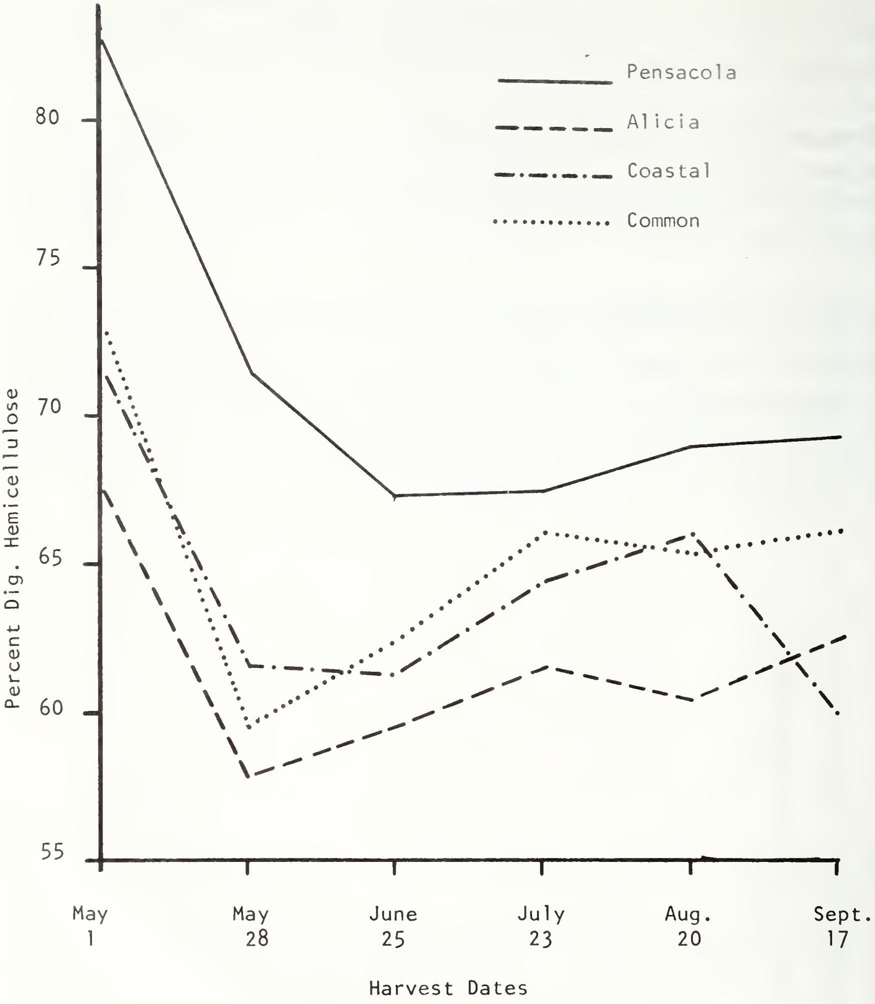

Figure 18.—Digestibility of forage hemicellulose of four perennial grasses, 1974-75.

Crude Protein Digestibility. Protein digestibility in Pensacola forage was consistently lower than that of the bermudagrasses (Figure 20). There was no significant difference in the protein digestion coefficients among the bermudagrasses at any harvest date. Protein digestibility tended to decline from early season to August, and increase in September to levels near those of May 1. Digestion coefficients ranged from 75.0 to 50.8 percent. Pensacola bahiagrass and common bermudagrass were most variable over the season in protein digestibility.

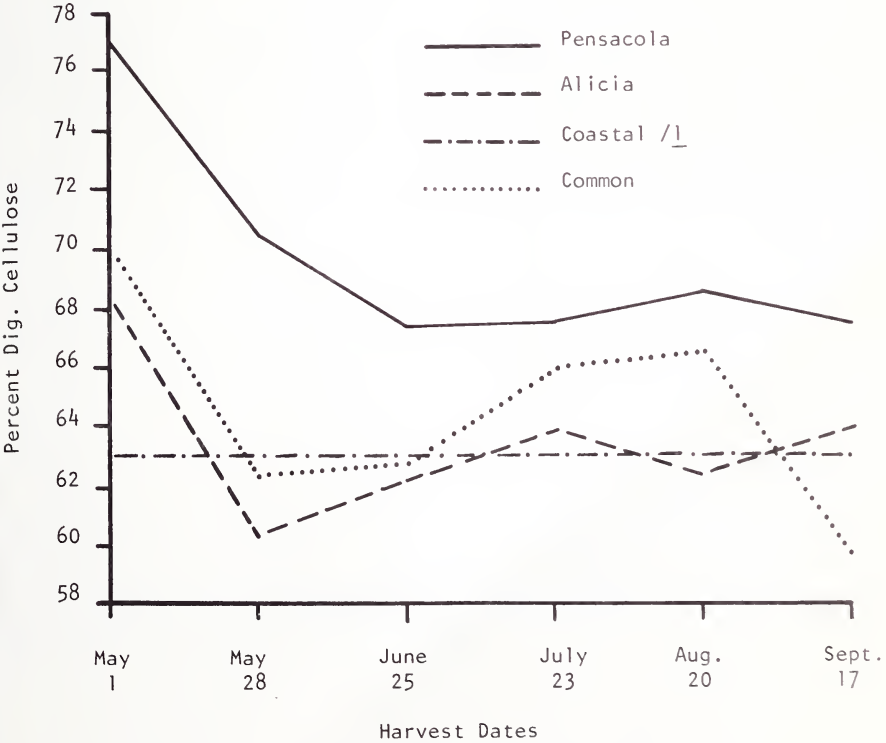

Figure 19.—Digestibility of forage cellulose of four perennial grasses, 1974-75.
[1]Horizontal line indicates seasonal means were not significantly affected by harvest date.

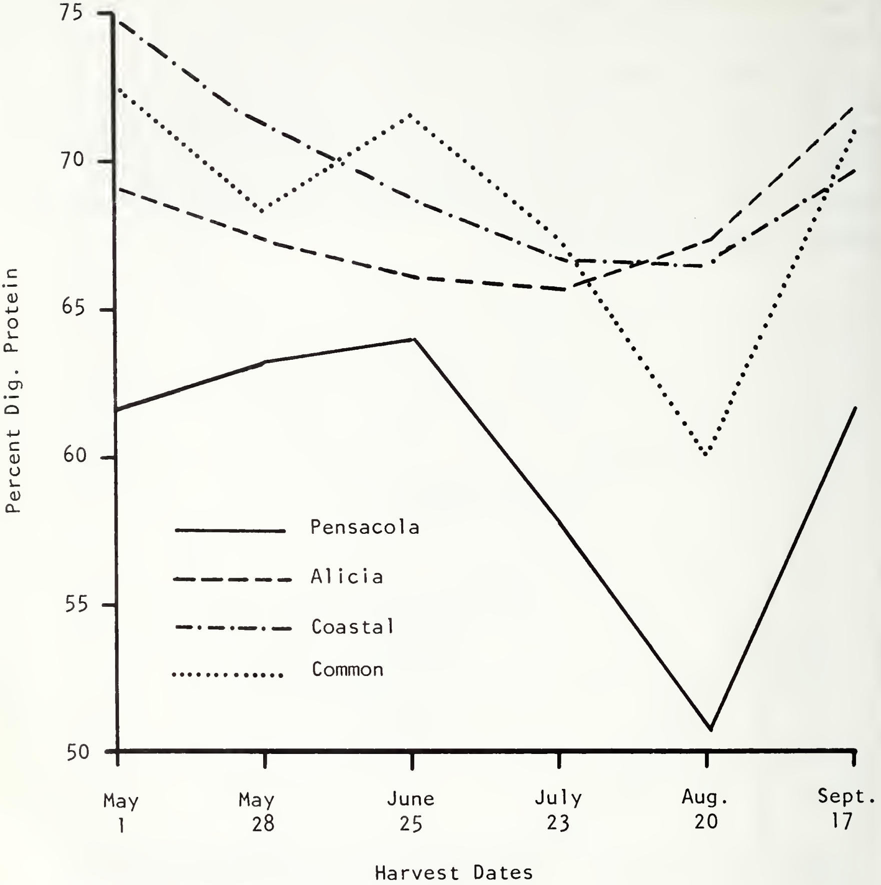

Figure 20.—Digestibility of forage protein of four perennial grasses, 1974-75.

Summary and Conclusions

Four perennial grasses, Alicia, Coastal, and common bermudagrasses and Pensacola bahiagrass, were grown for 2 years under field conditions and evaluated for forage yield, chemical composition, and digestibility. Alicia bermudagrass produced the highest total yield, followed by Coastal and common bermudas and Pensacola bahiagrass. The bermudagrasses were more tolerant of cool spring temperatures, and their yields were higher in the early spring than that of Pensacola. Yield of all grasses decreased after June 25.

Structural carbohydrate percentages were generally highest in Alicia and Pensacola. Pensacola was highest in ADF and cellulose, while Alicia was highest in CWC. Common was lowest in structural carbohydrate percentage, with the exception of hemicellulose.

Crude protein was not significantly different among grasses, with all forages containing the greatest quantity of CP at the May 1 and September 17 harvest dates.

Mineral content of all forages was above the minimal requirements for maintenance of ruminants on an all-forage diet. Calcium and phosphorus levels in the bermudagrass forages were not affected by season. Potassium percentages of all the grasses decreased as the season advanced.

There were highly significant positive correlations between in vivo and in vitro DDM values for each of the grasses tested. Pensacola was most digestible early in the growing season, and Alicia was least digestible after the first harvest. Coastal and common did not change significantly in digestibility with date of harvest.

Intake of the forages was not significantly different among grasses within harvest dates, but intake was generally highest in May and June and lowest in August.

Digestibility of Pensacola structural carbohydrates was consistently higher than that of the bermudagrasses. Generally, Alicia was lowest in carbohydrate digestibility of the three bermudagrasses.

These data reveal that bermudagrass yields were higher than that of Pensacola early in the season. Generally, season had a greater effect on quality of Pensacola than on bermudagrass forages. The quality of Pensacola was superior to the bermudagrasses early in the season, with no practical differences noted late in the season. Alicia was inferior to the other bermudagrasses in forage quality.

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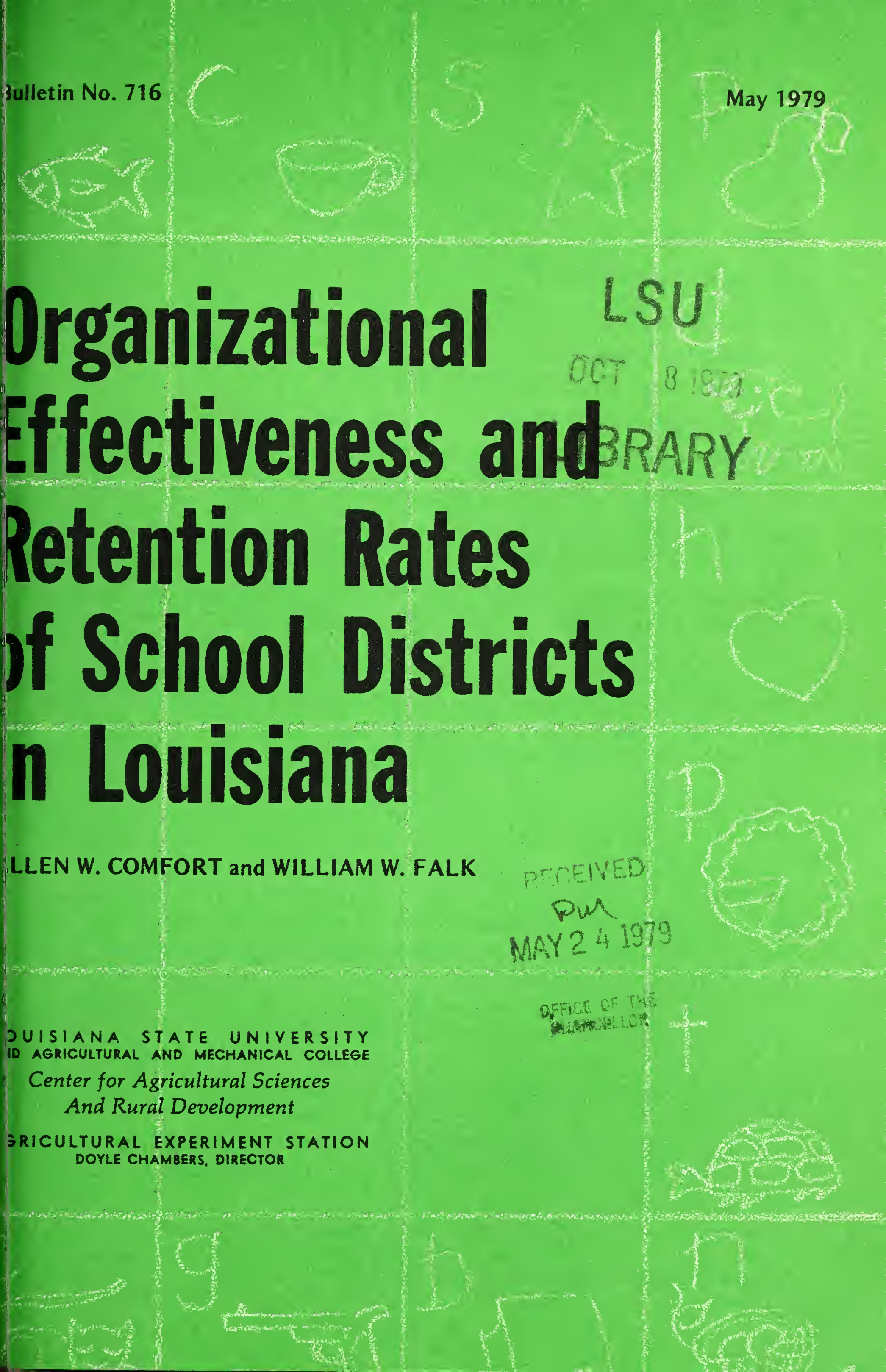

Bulletin No. 716

May 1979

Organizational Effectiveness and Retention Rates of School Districts n Louisiana

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Organizational Effectiveness and Retention Rates of School Districts in Louisiana

ALLEN W. COMFORT AND WILLIAM W. FALK*

Introduction

Since the mid-1970's, public education in Louisiana has found itself the object of a hue and cry for "accountability." This should have come as no surprise to analysts of public education nor should it have come as a surprise to those involved as professional educators. The call for accountability is a logical outgrowth of a long-term trend toward conceptualizing the schools as businesses. Callahan[1] has documented this trend and suggests that it originated at the turn of the present century when educators began thinking of themselves as professionals caught up in the "management" of education. The whole history of standardized tests is but one example of an attempt to exert a type of "quality control" on the educational "product." As some educators might put it, such tests are a "yardstick" by which they can measure how well students and teaching staff are doing. This approach to public education reached a sort of apex in the late 1960's with the advent of "performance based teaching." Large corporations such as RCA were induced to experiment with instruction whereby teachers were paid according to how well their students did on a series of standardized tests. The teachers, then, were contracted in such a way that their income was predicated on getting their students to do well on the tests. In this case, passing the tests became the over-riding concern of the educational process at the expense of more humanistic goals.

This report is not an attempt to determine what should be going on in the classroom. Rather, it is an attempt to document how well the schools are succeeding in what we state as an educational goal—i.e., keeing students in school through high school graduation. This in no way calls into question the quality of the product once produced; it merely determines—to keep in the business lexicon—how many products made it to the end of the assembly line. For many educators and parents, the goodness or badness of a school rests on its ability to help students on to graduation. This reasoning goes hand-in-glove with the emphasis in American society on attending college, with its prerequisite of first having been graduated from high school. Thus, the most successful high schools are those that send the greatest proportion of their students on to college.

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*Former Graduate Research Assistant and Assistant Professor, respectively, Department of Rural Sociology, Louisiana Agricultural Experiment Station.

[1] Raymond E. Callahan, *Education and the Cult of Efficiency*. Chicago: University of Chicago Press, 1962.

This study is the second in a planned series of reports on factors related to education in Louisiana. The initial study[2] dealt with historical trends in the state between 1950 and 1975, and considered such factors as total population, rural and urban population, school-age population, and various aspects of teacher training. In this report, as in the first one, there is an interest in assessing rural variables. In particular, we shall be reporting on the contrast between rural and urban parishes with respect to relative high school dropout rates and also the effect that the percentage of rural population has in a model of school district organizational effectiveness.

Although graduating or dropping out of school are acts of individuals, society-at-large has come to expect that it is the school's business to keep students in school. The system is encouraged by the way that schools are funded; the more students enrolled, the greater the level of support. Students are the schools' commodity and it is important that schools retain a large percentage of their students so that funding levels are maintained. The need to do this has been called by some the school's "holding power,"[3] while others have called it simply "retention."[4]

In this study, the retention rates for all public school districts in Louisiana have been examined. Our analysis has been done so that three types of analyses might be reported. First, the retention rates for the state as a whole for the last 15 years were calculated. This gives some idea of fluctuations in the rates historically. Second, as in our previous report, we again present analyses based on a comparison of the most urban and most rural parishes in the state. The most urban parishes are the ones with at least 65 percent of the population classified as urban, while the rural parishes are those with at least 65 percent of the population classified as rural. This kind of comparative analysis allows us to contrast the more heavily populated parishes with less heavily populated ones. The contrast is useful since historically it has been assumed that children in urban areas would be inclined to stay in school longer.[5] While this may have been the case historically, as we pointed out previously, the demands on the rural population have been changing and there is good reason to believe that the educational needs of the rural population will soon be no different from those of urban residents. This is especially the case in light of increasing complexity and technology in agriculturally related occupations. The third type of analysis deals with a model for the estimation of school district organizational effectiveness. This last analysis is the most complicated but it is presented in a straightforward fashion with the detailed statistical calculations reported in an appendix. The model is an attempt to use demographic and school district characteristics to predict retention rates. In an elemental way, the model is akin to evaluation research since it points out those factors that do and do not have an effect on retention rates.

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[2] William W. Falk and Allen W. Comfort, *Residential and Racial Trends for the School-Age Population and Public School Teachers in Louisiana*. Louisiana Agricultural Experiment Station, Bulletin No. 697, December, 1976.

[3] Daniel Schreiber, *The School Dropout*. Washington, D.C.: National Education Association, 1964.

[4] Allen W. Comfort, *School District Organization and Student Retention*. Unpublished M.A. thesis, Louisiana State University, Baton Rouge, Louisiana, December, 1977.

[5] W. J. Lyda and Verbinne P. Copenny, "Some selected factors associated with rural and urban dropouts in Laurens County, Georgia." *Journal of Negro Education*, 34 (1965): 96-98.

Methods and Procedures

Due to a rather unique characteristic of Louisiana school districts, complete coverage (100 percent) of the public school students in Louisiana in 1974-75 was possible in this research. There are 66 school districts in Louisiana. Sixty-four of these are based on the 64 parishes of Louisiana, with no overlap across parish boundary lines. In addition to these 64 districts, there are two other school districts, one within the city limits of Monroe and one in Bogalusa. These districts coincide with the geographical boundaries of the cities. Consequently, the data that have been collected are for the entire public school population. Although there was complete coverage of the 66 Louisiana public school districts, this is still a ''sample'' in that it occurs at one unique point in time.

It was of interest in this study to nearly replicate a study by Bidwell and Kasarda.[6] The data for this were readily available. Just as in the Bidwell-Kasarda study, our data were all previously collected by the federal and state governments.

Data for this project were obtained from the 1970 U.S. Census and the annual reports of the Louisiana Department of Education.[7] Data on children from low-income families, nonwhite population, rural population, and educational level of the parental risk population were obtained from the 1970 Census reports. Since school district geographical boundaries coincided with parish and city boundaries, there was no need to recode any of these data across census tracts. The data for the remaining variables were obtained from the annual reports of the Louisiana Department of Education.

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[6] Charles E. Bidwell and John D. Kasarda, ''School district organization and student achievement.'' American Sociological Review 40 (1975): 55-70.

[7] The educational data are from the Louisiana Department of Education *One Hundred Twenty-Third Annual Report for the Session 1971/72; One Hundred Twenty-Sixth Annual Report for the Session 1974/75.*

When operationalizing the variables for this study, the goal was to make these variables as similar as possible to those of Bidwell and Kasarda. In this study, the variables and their operationalization are as follows:

Environmental Conditions:

School District Size (SIZE)—operationally defined as the average daily attendance of the school district.

Fiscal Resources (RESOURCES)—the total of all revenues (local, state, and federal) received by the school district, divided by the average daily attendance of the district. This division tended to standardize the variable for the size of the district.

Disadvantaged Students (DISAD)—the percent of all children (ages 0-18) residing in the school district who were from families with incomes below the nationally defined poverty level of 1970.

Parental Education (EDUC)—the percent of males 20-49 years old and females 15-44 years old residing in the school district who had completed *at least* 4 years of high school education. This variable was based on the parental ''risk'' population—those who could be parents, not necessarily those who were.

Percent Nonwhite (PNONW)—the percent of the population residing in the school district who were classified by census definition as nonwhite.

Percent Rural (RURAL)—the percent of the population residing in the school district who were classified by census definition as rural residents. This variable was not included in the Bidwell-Kasarda model.

Structural Conditions:

Pupil-Teacher Ratio (PTRATIO)—the average daily attendance of the school district divided by the number of full-time teachers.

Administrative Intensity (ADMIN)—the ratio of administrators to classroom teachers. Administrators are defined as principals, superintendents, directors, supervisors, and business agents.

Professional Support Component (PROF)—the ratio of professional support staff to classroom teachers. The professional support staff is defined as librarians, guidance counselors, visiting teachers, agricultural agents, home demonstration agents, and medical personnel.

Staff Composition Conditions:

Certified Staff Qualifications (QUALIF)—the percent of the total certified staff with at least the Master's degree. The certified staff is defined as principals and classroom teachers.

Dependent Variable:

Retention (RET)—the retention rate (or "holding power") of the school districts. This was the percent of all ninth graders in the school district in 1971-72 who were graduated from high school in 1974-75.

Following the lead of Smith and Bertrand,[8] it was decided to dichotomize urban and rural parishes. While Smith and Bertrand chose to operationalize the "most urban" parishes as 65 percent urban or more and "most rural" parishes as 75 percent rural or more in 1950, we chose to use 65 percent in both cases to standardize our comparative framework. Additionally, the year 1970 was the basis on which the "most urban" and "most rural" parishes were delineated. The result was that nine parishes were included in the "most urban" category and 27 parishes were included in the "most rural" category (see Table 4 in Appendix). School districts are the unit of analysis used in this study. Consequently, the two separate school districts in Monroe and Bogalusa were also included in the "most urban" category since each district exists entirely in an urban area with a population of more than 2,500.

One goal of this study was to find some method to determine the extent of the dropout problem in Louisiana. The decision was made that a cohort analysis of retention rates could adequately explain the number of students dropping out of school. The idea was to discover how many entering high school students were retained by the school district until graduation. This was accomplished by first finding the number of ninth graders in each school district. Then the number of high school graduates three school sessions later was obtained. The ratio of these two numbers was the rate at which the school district retained students in school until graduation. This rate was calculated for roughly the last 15 years.[9] Retention rates for Louisiana are presented from the 1960-61 school session to the 1974-75 school session.

The model to estimate school district organizational effectiveness consists of six environmental variables of the school districts, three variables regarding the district structure, and one variable of staff composition (Figure 1; and Figure 3 in Appendix). These variables are linked in a casual model to student retention rates for the school district. The environmental

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[8] Marion B. Smith and Alvin L. Bertrand, *Rural Education in Transition: A Study of Trends and Patterns in Louisiana.* Louisiana Agricultural Experiment Station, Bulletin No. 576, December 1963.

[9] This number does not directly take into consideration in- and out-migration. However, we would anticipate that this would not be a major problem here. First, in- and out-migration might largely cancel each other out. Second, we are dealing with a very short period of time in which the rates would probably increase or decrease only slightly, if at all, due to migration.

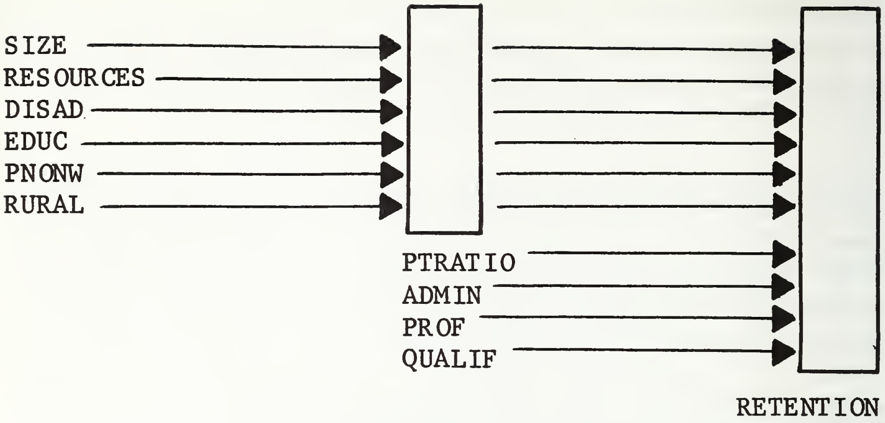

Figure 1.—A model of school district organizational effectiveness for Louisiana.

conditions are size, monetary resources, nonwhite population, percent of children from low-income families, educational levels of the parental risk population of the school district, and percent of the population of the school district classified as rural residents. The school district structural variables include the pupil-teacher ratio, the ratio of administrators to classroom teachers, and the ratio of the supporting professional staff to the classroom teachers. The staff composition variable pertains to the qualification level of the certified staff.

Basically, the variables in this model are temporarily ordered into three stages. The environmental variables are assumed to occur first in time. Logically, these environmental constraints would affect the way in which the school district would be organized and the type of structure that would exist. The intervening variables in this model (the second stage) are the district organizational structure variables and the staff composition variable. The three-stage model is completed by the dependent variable of school district student retention rates.

A variable measuring the percent of the district population who are rural residents has been included in this model. This variable is included with other environmental conditions because it, too, describes the ecological conditions that exist within each school district. It was felt that this variable was important because of the large proportion of the Louisiana population that is classified as rural (approximately 34 percent in 1970). In addition, most texts on rural sociology express the view that rural residents have a life style that is different from their urban counterparts. The writings of Smith and Zopf, Nelson, Rogers and Burdge, and even Sorokin and Zimmerman indicate that there *will* be differences in schools and in students due to a rural life style.[10]

This report is organized so that summary data are first presented on the statewide retention rates. Comparisons between the most rural and the most urban parishes concerning retention rates are then presented. Next, conventional regression analysis is used to report the predictive ability of the organizational model for Louisiana school districts. The final section of the report is included to discuss the implications of selected findings that are of interest.

Data Analysis

Retention Rate Trends

It might generally be assumed that retention rates are steadily increasing due to the great amount of attention being given to education. Such is not the case in Louisiana, however. Over the last 15 years the statewide public school retention rate has increased from 59.1 percent during the 1960-61 school session to 66 percent during the 1974-75 school session, but there have been as least two periods when substantial declines took place (Figure 2; and Table 5 in Appendix). During the early 1960's the retention rate increased steadily to a high of 67.4 percent in 1964-65. The next school year, however, the percentage of ninth graders retained in school until graduation decreased. The statewide retention rate did not again reach a point this high until the 1968-69 school session when 68.4 percent of the ninth graders had been retained until high school graduation. The next year there was a tremendous decline in this figure that did not slow until the 1971-72 school session. From the 1971-72 school session to the present the retention rate for the state has varied. It has not yet reached the high of 68.4 percent that was obtained in 1968-69.

Rural-Urban Comparisons

In 1974-75 the retention rates by school district ranged from a low of 49 percent in Claiborne Parish to a high of 80.4 percent in Winn Parish (Table 1). Generally, there were proportionally more most urban school districts than most rural school districts in the group with the highest retention rates. The median retention rate for the state was 64 percent. Sixty-four percent of the most urban districts had retention rates higher than the median rate for the 66 public school districts (Table 2). However, 63 percent of the most rural districts had retention rates lower than the median rate.

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[10] See T. Lynn Smith and Paul Zopf, *Principles of Inductive Rural Sociology*. Philadelphia: F. A. Davis Company, 1970; Lowry Nelson, *Rural Sociology*. New York: American Book Company, 1955; Everett M. Rogers and Rabel J. Burdge, *Social Change in Rural Society*. New York: Appleton-Century-Crofts, Inc., 1972; Pitmin Sorokin and Carl C. Zimmerman, *Principles of Rural-Urban Sociology*. New York: Henry Holt and Company, 1929.

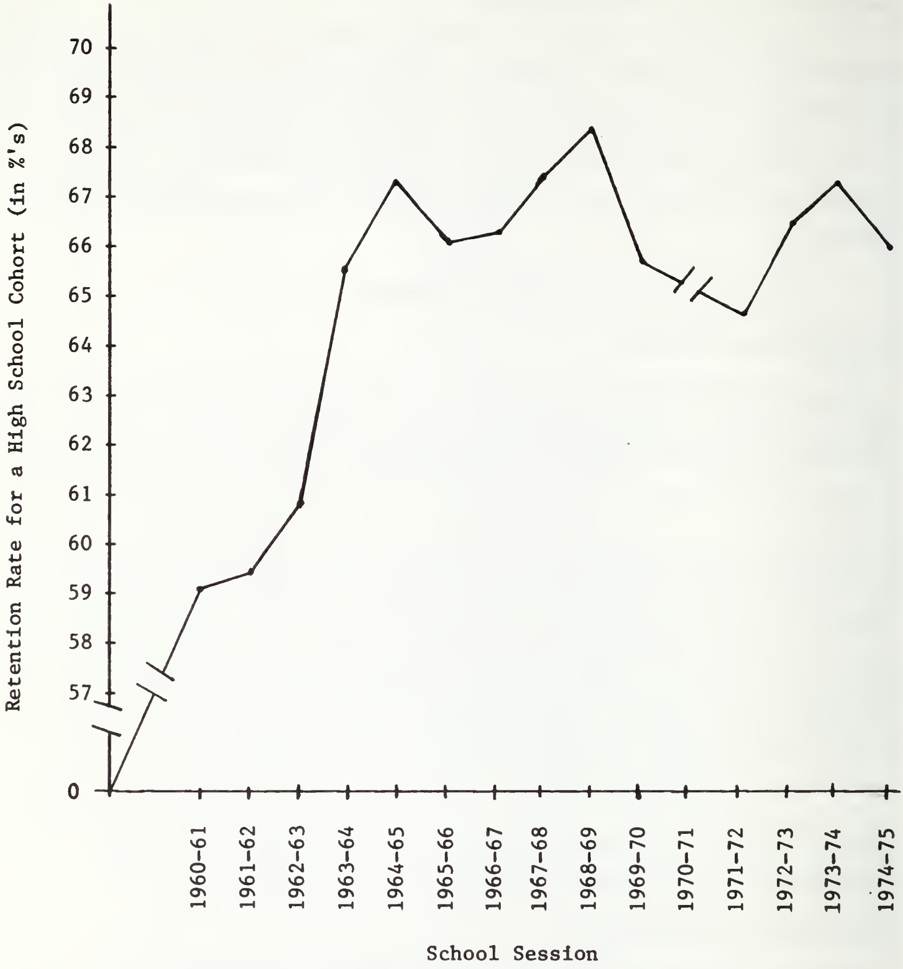


Figure 2.—Trends in the Louisiana retention rate.

All of the most urban school districts had retention rates of at least 60 percent in 1974-75, but 41 percent of the most rural school districts had retention rates below this point (Table 1). None of the most urban or the most rural school districts had retention rates above 80 percent. The school districts with retention rates this high fall into the ''other'' category that is neither tremendously rural nor urban.

The variables included in the model to predict school district organizational effectiveness (i.e., ''retention'') can be discussed regarding the most rural and most urban school districts. The mean levels for each type of district are reported in Table 3.

The mean retention rate was much higher in the 11 most urban school districts. On the average, the most urban districts were retaining 66.5

Table 1.—Retention rates by school district in 1974-75[1]

School district	Rate (%)[2]	School district	Rate (%)
1. Winn	80.4	34. Madison	63.9
2. St. Martin	80.2	35. Catahoula*	63.7
3. Lincoln	78.3	36. Grant*	63.7
4. Lafourche	77.9	37. Webster**	63.6
5. East Baton Rouge**	74.2	38. City of Monroe	63.4
6. Calcasieu**	74.1	39. Orleans**	63.3
7. Allen	73.7	40. St. Tammany	63.3
8. Natchitoches	73.3	41. Vernon	63.1
9. Jackson*	73.3	42. Tensas*	62.7
10. Acadia	72.7	43. Jefferson**	62.5
11. West Feliciana*	71.0	44. Morehouse	62.1
12. Union*	70.8	45. Sabine*	61.9
13. Caddo**	70.6	46. St. Mary**	61.2
14. DeSoto*	70.6	47. St. Charles*	60.8
15. Cameron*	70.5	48. East Feliciana*	60.4
16. Vermilion	70.2	49. Washington	59.8
17. Ascension*	68.7	50. Concordia	58.7
18. Bienville*	68.6	51. Pointe Coupee*	57.8
19. Beauregard	68.0	52. Red River*	57.4
20. Iberia	67.8	53. Assumption*	57.2
21. St. James*	67.8	54. Franklin*	57.0
22. Jefferson Davis	67.3	55. Tangipahoa	56.7
23. Avoyelles*	67.1	56. St. Helena*	56.5
24. Bossier	66.6	57. Caldwell*	55.5
25. Lafayette**	66.6	58. LaSalle*	55.3
26. City of Bogalusa**	65.8	59. Evangeline	55.1
27. St. Landry	64.9	60. West Baton Rouge	54.8
28. St. Bernard**	64.9	61. East Carroll	54.4
29. Terrebonne	64.6	62. Richland*	52.4
30. Ouachita**	64.4	63. Plaquemines*	51.5
31. Livingston*	64.2	64. West Carroll*	51.4
32. Rapides	64.1	65. Iberville*	49.4
33. St. John	64.1	66. Claiborne	49.0

[1] Retention rates are based on the percent of a 9th grade cohort still in high school at graduation in the senior year.

[2] Some retention rates may seem to be equal due to rounding. Actually, there are no "ties" and school districts are listed in descending order.

*Most Rural school district.

**Most Urban school district.

percent of the ninth graders to high school graduation, while the most rural districts were retaining 61.7 percent.

Some of the results are quite surprising. Even though the most rural school districts had a lower mean retention rate than the most urban school districts, these rural districts had a higher administrative intensity (9.36 percent to 5.95 percent), a larger ratio of professionals to classroom teachers (8.30 percent to 6.49 percent), and a lower pupil-teacher ratio (18.59 to 19.49). In addition, when the RESOURCE variable was recalcu-

Table 2.—Retention rates above or below the median in 1974-75

Classification	School districts above median	School districts below median	Total
Most urban	7 (64%)	4 (36%)	11 (100%)
Other	16 (57%)	12 (43%)	28 (100%)
Most rural	10 (37%)	17 (63%)	27 (100%)
Total	33 (50%)	33 (50%)	66 (100%)
N = 66 Median = 64.0%			

Table 3.—Mean values for the variables in a Louisiana school district effectiveness model in 1974-75

Variables[1]	Most rural school districts	Other school districts	Most urban school districts
RET	61.70%	65.70%	66.50%
PTRATIO	18.59	18.97	19.49
ADMIN	9.36%	7.80%	5.95%
PROF	8.30%	7.48%	6.49%
QUALIF	33.47%	33.67%	37.78%
RESOURCE	$1,308.10	$1,215.00	$1,237.10
DISAD	41.34%	36.54%	25.68%
EDUC	25.90%	28.86%	39.45%
PNONW	35.35%	31.53%	27.40%
	N = 27	N = 28	N = 11

[1] RET = retention rate for the district; PTRATIO = pupil-teacher ratio; ADMIN = ratio of administrators to classroom teachers; PROF = ratio of professional staff to classroom teachers; QUALIF = percentage of staff with at least a Master's degree; RESOURCE = total revenues per pupil for the district; DISAD = percentage of children from poverty level families; EDUC = percentage of males (20-49) and females (15-44) with at least a high school education; PNONW = percentage of district classified as non-white.

The variables SIZE and RURAL were not included since their values would have been meaningless in this type of analysis.

lated on a per-pupil basis, the most rural school districts had a larger per-pupil expenditure than did the most urban districts ($1,308.10 to $1,237.10).

However, on those variables where the most urban school districts had the "better" measure, the differences were often much greater. The most urban districts had a great deal fewer disadvantaged children (25.68 percent vs. 41.34 percent) and many more better-educated parents (39.45 percent vs. 25.90 percent). Additionally, the proportion of teachers with advanced degrees was larger in the most urban school districts (37.7 percent to 33.47 percent).

The Organizational Model

A series of hypotheses were developed concerning the relationships that would occur among the variables in the organizational model. The first hypothesis was that the environmental conditions (district size, fiscal resources, disadvantaged children, parental education, rural population, and nonwhite population) would be related to and affect the district structural variables (pupil-teacher ratio, administrative intensity, and professional support component). Fiscal resources, parental education, and the rural population significantly affected the pupil-teacher ratios (see Table 6 in Appendix for a more sophisticated treatment of these relationships). The administrative intensity was significantly affected by school district size, fiscal resources, and percent disadvantaged children. None of the environmental conditions had a significant effect on the professional support component. Much of the variance was accounted for in the pupil-teacher ratio (56 percent) and the administrative intensity (64 percent), but the professional support variable had comparatively little explained variation (28 percent). This hypothesis received only moderate support.

The second hypothesis was that environmental conditions would be related to and affect staff composition. This hypothesis was not supported at all. Only one relationship was significant (that from RESOURCES to QUALIF) and only 18 percent of the variance in the staff composition component was accounted for by the environmental condition.

The third hypothesis was that environmental conditions, district structural variables, and staff composition would be related to and affect the school district retention rate. Also, the effects of the exogenous variables would be mediated by the intervening variables. There was little or no support for this relationship. One significant effect was found and 21 percent of the variance was explained. Only the staff qualifications seemed to significantly affect the school district retention rates. In addition, only one exogenous variable showed signs of large mediated effects with much of the effect of fiscal resources mediated by staff qualifications (49.7 percent).

Interpretation of Results

Retention Rate Trends

Retention rates in Louisiana have shown considerable variation in the last decade. The most significant decrease was from 1968-69 to 1971-72. This time period roughly corresponds to that time when desegregation hit full force in Louisiana. Two possible explanations for this decreasing retention rate are (1) that parents removed their children from public schools and placed them in nonpublic schools to graduate, or (2) that children left the public schools and did not continue their education at any other school, public or private. This was a time when parents in Louisiana were not accustomed to a racial mixture in the public schools and many of them went to great lengths in attempting to prevent it. This is obvious from the fact that the number of students entering public high schools *decreased* during this time period. The importance of the emerging nonpublic schools is reinforced by the fact that the state retention rates in public schools still have not regained the high level of 1968-69. If higher status students are in nonpublic schools, then on the average slightly lower status students who are less likely to graduate are in the public schools. The result is lower retention rates.

Rural-Urban Comparisons

Generally, the results from the comparison of the most urban and most rural school districts were to be expected. The most urban areas did have higher retention rates, as had been suggested by other research and the literature. At times it has been implied that rural people don't value education as much as urban people. Others have suggested that rural youth *must* leave school to take jobs or help out at home. Whatever the case, the Louisiana school data have shown that urban districts retained more youth than did rural districts. A partial explanation for this is that more teachers with advanced degrees were in the urban school districts. It seems that the urban areas were able to attract more of these better-educated teachers.

Surprisingly, the most urban school districts had lower percentages of the nonwhite population and disadvantaged children. Normally, these groups are more likely to be found in higher percentages in urban districts. Nonwhites in the Deep South have supposedly migrated to urban areas, but this does not seem to be the case in Louisiana. Proportionally, more disadvantaged children and more nonwhites still reside in the rural school districts. However, because this is the case the higher retention rate in urban school districts is more easily explained. Disadvantaged children and nonwhites seem to be associated with lower status and with lower retention rates. Since these variables were lower in the urban districts, retention rates were higher.

It seems logical to assume that the parental education level is much higher in the urban districts. Historically, urban areas have had better-educated populations and there is no reason to believe that this gap has yet been bridged. Possibly the fact that these parents are better educated shows that they expect more of their children—in this case, high school graduation. Hence, the retention rates were higher in urban areas.

The variables that were "better" in the most rural school districts may be more difficult to interpret. One might expect that increased administrative intensity and professional support would be associated with higher retention rates. Such is not the case in Louisiana. The most rural school districts had higher mean levels for ADMIN and PROF, but lower mean levels for RET. This is probably due to the fact that a certain number of administrators and professionals will be required in all schools; it is an economy of scale. Because rural areas had these required administrators and professionals, but fewer classroom teachers, the ratios tended to be higher.

The higher mean level of per-pupil expeditures in most rural school districts was also surprising. This suggests that urban areas may get "more for their money." For example, an urban school might buy expensive scientific equipment, then use it for six chemistry classes. A rural school might need the same equipment to teach chemistry even when there is only one class. Inflation could also have an impact—consider gasoline. An urban school bus might run a route of just a few blocks before it is filled with students. However, a rural school bus may have to run a route of several miles (at great expense) before completing it. Obviously, urban areas spend more money, but proportionally the most rural school districts spend more per pupil.

The lower pupil-teacher ratios in rural school districts is interesting. It had been assumed that PTRATIO's would be high in rural areas. In actuality, they were lower in rural districts than in urban ones (18.59 to 19.49). This may be due to fewer students in rural schools. State law requires that a certain number of courses *must* be taught. If a relatively few students are rationed out among these courses, the PTRATIO's would be lower.

The Organizational Model

In the model tested in this study, only a small amount of the variance was accounted for (21 percent) and none of the hypotheses was completely supported; consequently, the task of interpreting these data was quite difficult. The first hypothesis was concerned with the effect of the environmental variables on the district structural variables. It had been hypothesized that PTRATIO would be positively affected by SIZE and RURAL, and inversely affected by RESOURCES, EDUC, and PNONW. Only two of these relationships were supported.

The strongest relationship was found between RESOURCES and PTRATIO. It would seem plausible to assume that districts with more money could (1) afford to increase the number of teachers, and (2) would do so, thereby reducing the pupil-teacher ratios. Since this was the case in the Louisiana public school districts, apparently those districts that had more money did in fact hire more teachers, thereby lowering the pupil-teacher ratios.

The other variable to significantly affect PTRATIO was RURAL. The assumption was made that rural areas would have a hard time retaining teachers. In addition, it was assumed that these areas would probably have less fiscal resources with which to attract or to add new teachers. Consequently, getting teachers in rural areas might be difficult and the number of pupils for each teacher would be high. As shown in the mean comparisons, our assumptions about the most rural districts were incorrect—they had comparatively more resources and a lower pupil-teacher ratio. However, this was true only on the average. It must be recalled that there are far more rural than urban school districts, and there is more variability between them. Thus, in our model the percent rural turns out to be a good indicator of PTRATIO. This suggests that the percent rural and PTRATIO vary together—as one increases, so does the other. In general, then, the PTRATIO will go up as the percent rural goes up, even though the rural mean PTRATIO was less than the urban mean.

The assumption had been made that as school district size increased, the pupil-teacher ratio would increase also. A greater number of students would be assigned to a fixed number of teachers. The results should be higher PTRATIO's. Basically this type of effect was found. However, even though this effect was large, it was not a significant relationship. This suggests that sometimes large school districts may have lower PTRATIO's and there is not as much variation between large and small districts as might have been expected (the range was from 15.3 to 21.5). This was probably due to other characteristics that are associated with large districts, such as an urban lifestyle, and a different utilization of available resources.

The most surprising variable affecting the pupil-teacher ratio was the parental education level. It had been predicted that districts with higher education levels for parents would be likely to have lower pupil-teacher ratios. This is because more highly educated adults would be more likely to want to reside in areas where their children could get a ''quality'' education. This ''quality'' education could be defined as classrooms with lower pupil-teacher ratios where the student would be likely to get more individual attention from the teacher. However, the data for Louisiana public school districts indicated a positive relationship between these two variables. In other words, districts with higher parental education levels also had higher PTRATIO's. It is difficult to imagine that more highly educated parents would *want* their children to be in districts with higher PTRATIO's. Our explanation of this is based on our understanding of the use of public and private schools in Louisiana.

First, it should be noted that Louisiana has a large Catholic population. Historically, Catholic parochial schools have been heavily supported and have even received favorable treatment in the state legislature wherein funds have been appropriated for them. While it is merely speculation at this point, we suggest that the peculiar effect of EDUC on PTRATIO is a byproduct of the large attendance at parochial (and private) schools. It seems reasonable to speculate that those students attending parochial schools, which require tuition, will be more likely to come from families who can afford to send them. In short, a disproportionate number of students attending parochial schools will come from families of higher socioeconomic status. The result of this is to inflate the number of students attending public schools who came from families of relatively low socioeconomic status for whom the parochial schools would be an unaffordable financial burden. This seems especially likely in the urban areas of the southern part of the state, which are also the most heavily Catholic (areas such as New Orleans, Lafayette, and Lake Charles). Thus, these areas may have parents with higher education levels residing in them, but many of these parents may be Catholic and may be sending their children to private schools. For them, then, the schools with higher pupil-teacher ratios are not a problem because while they are *in* a particular school district they are not necessarily *of* it.

Second, it should be noted that as a result of widespread implementation of school desegregation practices, private school academies began to appear, particularly in the early 1970's. Again, it is the parents with the higher education and income who can most easily afford to send their children to these schools. Thus, while they live in a particular district, it does not necessarily follow that their children will be attending the public schools.

The next area of concern involved the effect of the environmental variables on the administrative intensity of the school district. Of the four relationships that were considered, all effects were in the suggested directions with three of the relationships being significant. It was assumed that increasing school district size would not necessarily require more administrators. More teachers might be necessary, but basically the same number of administrators would suffice. The result would be that the ratio of administrators to classroom teachers should decrease. This seemed to be the case with the Louisiana public school districts. A negative relationship was found between these two variables, indicating that as the school district size increased, the administrative intensity of the district tended to decrease.

The relationship concerning RESOURCES and ADMIN seemed quite logical. A school district with more money to spend would be more likely to have more special programs and more need for extra administrators. It may not be necessary to increase the number of administrators just because the school district size increases, but if there is more money available, it is likely that more administrators would be hired. Data for Louisiana supported this assumption. Those districts with more fiscal resources tended to have a larger administrative intensity.

The incidence of disadvantaged children often is associated with special programs to care for their needs. Since this is the case, more administrators may be required to supervise these extra activities. The most surprising thing about this relationship for the Louisiana data was its large size. This was by far the largest effect found for *any* relationship in the entire model. Again, this suggests that *the* main predictor of the proportion of administrators in a district will be the proportion of disadvantaged children, for whom there are more remedial and federally subsidized programs (e.g., Title I programs) which require supervision.

The final assumption concerning ADMIN suggested a positive effect by the RURAL variable. Just as it was assumed that the number of administrators would remain constant regardless of SIZE, it was also assumed that this number would remain constant regardless of rural background. The only difference would be that as the rural population increases, the number of required teachers would decrease. In short, there is an economy of scale in district organizational matters. This should cause ADMIN to increase for rural districts. Generally, school districts with larger proportions of rural residents in the population also tended to have a larger ratio of administrators to classroom teachers.

All six of the environmental variables were hypothesized to have a direct effect on the professional support component (PROF) of the school districts. None of these relationships was supported by the data; consequently, interpretations are difficult. It had been anticipated that larger districts (SIZE) and those with more money (RESOURCES) would need and/or could afford more professional staff. Also, in areas where the parents are highly educated (EDUC), there should be greater pressure for more counselors, etc., to adequately guide the children. Since nonwhite (PNONW) and disadvantaged students (DISAD) have tended at times to be poorer students, they often need more extra help in the form of specialists and remedial instruction. Finally, a certain number of professionals would always be necessary, even in rural areas (RURAL) with fewer teachers; hence, this ratio of professionals to teachers should be higher. Nothing can really be said about this variable, however. Three of the coefficients were so small (DISAD, EDUC, and PNONW) that they had no effect on PROF whatsoever. The only variable anywhere close to significance was RESOURCES. Generally, school districts with more fiscal resources tended to have larger ratios of professionals to classroom teachers.

The second hypothesis was concerned with the effect of the environmental conditions on the staff composition variable. It was anticipated that SIZE, RESOURCES, and EDUC would have a positive effect on QUALIF, while DISAD, RURAL, and PNONW would have an inverse effect. Only one of these relationships was supported by the data.

Bidwell and Kasarda had posited that SIZE would be an indicator of community size. Larger communities should have a larger collection of well-qualified teachers. Consequently, the QUALIF variable should be higher for the larger school districts. Such was not the case in Louisiana. As school district size increased, QUALIF tended to decrease. This effect was very small, though. The problem that exists is in determining what it is about large school districts that results in a lower ratio of teachers with advanced degrees. This may be a function of a larger labor market in urban areas; thus, as size increases it may be necessary to continually add new teachers who do not have advanced degrees. It is most common for a teacher to get his or her first teaching job without an advanced degree. If a school district hired a number of these teachers, this could conceivably cause the QUALIF ratio to decrease.

The hypothesis was made that as school districts had increasing financial resources, they would be able to afford and to attract better-qualified (i.e., more educated) teachers. This relationship was supported by the data. As the fiscal resources of a district increased, the ratio of teachers with advanced degrees to those teachers without advanced degrees increased also. This is possible because districts with more money should be able to pay the higher starting salaries necessary to attract better-qualified teachers. Also, districts with more resources may have more special or "extra" programs that require teachers with advanced degrees.

It was also hypothesized that more highly educated parents would want the best possible education for their children, and hence would want more highly educated teachers for their children. Consequently, more highly educated parents were assumed to live in districts where the QUALIF ratio would be higher. This relationship was supported by the very large effect found in the Louisiana data. Louisiana school districts with higher levels of parental education also had higher ratios of teachers with advanced degrees to teachers without advanced degrees.

It was hypothesized that the rural population and the nonwhite population would be inversely related to the qualifications of the staff. Rural areas would be hard-pressed to attract more highly educated teachers to their school districts. This relationship was not supported by the data. A low negative effect was found between RURAL and QUALIF. This suggests that those school districts with large rural populations may have had fewer teachers with advanced degrees, but the rural-urban difference was not as great as we had anticipated.

Next we examined the effects of all of the exogenous and the intervening variables on the school district retention rate. Theoretical interpretations are difficult because only 21 percent of the variance was accounted for and only one relationship (of 10) was significant. Of the environmental variables, it was felt that SIZE, DISAD, RURAL, and PNONW would be inversely related to school district retention rates. It has been suggested that as the size of a school increases, some students become alienated from the system. If these students need help, but do not get it, they may be less likely to graduate. For these data, however, a positive relationship was found. It seems that as school district size got larger, the retention rate increased.

Possibly this is a result of the fact that the better-educated teachers are more likely to be in large areas, and these teachers help keep students in school. More support is offered for this in our discussion of the QUALIF variable's effect on RET.

DISAD and PNONW could be considered measures of the lower status population. As such, these groups seem to be less likely to finish school. Both measures were in the predicted direction. DISAD seemed to have a very strong effect on RET, but the effect of PNONW was fairly weak. Consequently, school districts with greater proportions of disadvantaged children were likely to have lower retention rates. It seems that poorer families (as measured by children below poverty level) tend to perpetuate their status by failing to get an adequate education. The same basic idea is true for the nonwhite population, but in this case the relationship was not as evident.

At times it has been suggested that rural residents do not value education as much as others do, and that they are more likely to start working full-time at an earlier age. If this is so, rural students may often be less likely to stay in school. The Louisiana data offer some support for these assumptions. While the effect was not significant, it was in the predicted direction. It seems, then, that school districts with larger rural populations tend to have lower retention rates.

The environmental conditions of RESOURCES and EDUC were hypothesized to have a positive effect on RET. The fiscal resources of the district seemed to have no effect on the retention rate. Nothing can really be said about this relationship. Concerning EDUC, it had been logical to assume that more highly educated parents would encourage their children to get an education also; hence, districts with high levels of parental education would also have high retention rates. Such was not the case in Louisiana. A rather large effect was found ($P_{KD} = -.240$) which suggested that as the parental education level of a district increased, the retention rate of the district decreased. It seems impossible to fathom that as more parents get a high school education, their children get less education. A possible explanation concerns the existence of nonpublic schools. It is entirely possible that in the school districts with high parental education levels, these better-educated parents may be more likely to send their children to nonpublic schools. Consequently, these parents are included in the EDUC variable, but their children are not included in the RET variable. This is the same line of discussion presented for the paradoxical effect of EDUC on PTRATIO.

The result is that none of the environmental conditions seemed to affect the retention rate. The intervening variable of PTRATIO was hypothesized to have an inverse relationship with RET. Students in schools with lower PTRATIO's would be likely to get more special attention. This added attention and closer atmosphere should lead to higher retention rates. The

Louisiana data failed to show this relationship. The coefficient was in the predicted direction, but it was so small that no effect can really be suggested for PTRATIO.

The intervening variables of ADMIN, PROF, and QUALIF were hypothesized to be directly related to RET. It was assumed that more administrators and professional staff would be available to help the potential dropouts. For example, more counselors and teaching specialists may give the personal attention to a potential dropout that he needs. More administrators may be associated with special programs aimed at keeping these students in school. The Louisiana data did not support these relationships. The effect of ADMIN on RET was quite large, but it was not significant. Generally, though, it seems that as the administrative intensity of the school district increases, the retention rate increases also. The relationship between PROF and RET was almost zero, yet in the literature, increasing the professional staff was often suggested as the best way to reduce the dropout rate.

The assumption was made that teachers with more education would be better qualified to keep the potential dropout in school. Whatever the dynamics of this, it remains that this was the only variable that significantly affected the school district retention rates. Those districts with increasing levels of staff qualifications were likely to have higher retention rates. This was an important finding since the interpretation of the regression coefficient here is that if staff qualifications are increased, then the retention rate will also be increased. Thus, the greater the staff qualifications, the greater the retention rate.

Only the mediated effects remain to be discussed. One exogenous variable—RESOURCES—had a substantial amount of mediated effects. This is not too surprising. It is very difficult to imagine how money, by itself, could raise the retention rate. Just having the resources is not going to cause more students to graduate from high school. The solution is in the ways the fiscal resources are spent. This is what the mediated effects show. The intervening variable of QUALIF best mediates the effects of RESOURCES on RET. Fiscal resources cannot raise retention rates, but the resources *can* increase the number of better-educated teachers and these teachers can then help raise the retention rate.

The results of the data seem to indicate that the utilization of a variable to measure the rural population (or its obverse, the urban population) is a necessary condition in school district organizational research. The RURAL variable significantly affected only one of the intervening variables, but in *every* case the effect was in the direction that was expected. Also, in every situation, the effect seemed large enough to assume that it was not entirely by chance that the results were in that direction. The rural population did not significantly affect the school district retention rate, but, again, it was a fairly large effect in the assumed direction. In short, human ecology, in a school district, seems to be an important variable in the general understanding of school district organization.

Summary and Conclusions

This study is the second in a projected series concerning education in Louisiana. An attempt has been made to analyze the organizational effectiveness of Louisiana public school districts. The logic utilized was that one measure of organizational effectiveness or organizational ''success'' is the ability of the school districts to retain their high school students until graduation. Consequently, the retention rates and the factors affecting them were analyzed to discover the effectiveness of the public school district organization.

The current study has used data from the 1970 U.S. Census of the population of Louisiana and the annual reports of the Louisiana Department of Education to assess trends in Louisiana education. The units of analysis have been the state, the school district, and the most urban and most rural school districts (defined as 65 percent urban or rural).

Summary Highlights

1. The retention rate for Louisiana has increased from 59.1 percent during the 1960-61 school session to 66 percent during the 1974-75 school session.

2. The highest retention rate for Louisiana was 68.4 percent, obtained during the 1968-69 school session.

3. A decline in the Louisiana retention rates occurred during the period when desegregation reached its peak (from 1968-69 to 1971-72).

4. The retention rates for public school districts ranged from a low of 49 percent in Claiborne Parish to a high of 80.4 percent in Winn Parish.

5. The median retention rate for public school districts was 64 percent. The mean retention rate was 64.2 percent.

6. The most rural school districts had greater administrative intensity, a greater professional support component, lower pupil-teacher ratios, and larger per-pupil expenditures.

7. The most urban school districts had greater staff qualification levels, higher parental education levels, lower levels of disadvantaged children, and smaller proportional nonwhite populations.

8. The mean retention rate for the most urban school districts was 66.5 percent. For the most rural school districts it was 61.7 percent.

9. Sixty-four percent of the most urban school districts had retention rates *higher* than the median, whereas 63 percent of the most rural school

districts had retention rates *lower* than the median.

10. The administrative intensity of the school districts was significantly depressed by the size of the district.

11. Increases in fiscal resources and the disadvantaged population in the district were associated with increases in administrative intensity.

12. The pupil-teacher ratio of the district is significantly increased by an upward change in the rurality of a district and the percentage of the parental risk population with at least a high school education.

13. An increase in fiscal resources has a significant depressing effect on pupil-teacher ratios.

14. The qualifications of the certified staff were significantly affected (positively) only by fiscal resources.

15. The only structural variable of the school districts to significantly affect retention was the qualifications of the certified staff. There was a positive relationship between the two variables.

16. As a predictor of dropout rates, this model explained about 21 percent of the total variation in student retention rates among Louisiana public school districts.

17. A variable to measure the rural population (as an ecological factor) is a necessary condition in school district organizational research.

Implications

From our analysis, three findings merit some further discussion because each of them implies that a social accounting of education is a worthwhile project. First, the general retention rates in Louisiana have increased through the years with a leveling off in the last few years. This indicates that retention rates may have reached an apex of sorts. In the most ideal of circumstances, we might posit that everyone would graduate from high school (and, perhaps, even college); this would be in keeping with the humanistic goals of some educators (e.g., John Dewey) and the more vocational interests of many state legislatures (to include Louisiana). However, it is apparent that not everyone will stay in school long enough to graduate, and, from a labor economics standpoint, this may not be such a bad thing since the labor market is hard-pressed to absorb all potentially employable persons as it is. Additionally, as educational attainment levels have increased, historically the requisites for employment have changed also. If present trends continue, we can say that roughly two-thirds of the students entering high school in Louisiana will graduate. Put differently, this means that one-third of all public school children will *not* graduate from high school and will have to compete in and be absorbed by a labor market that has increasingly higher requisites for job placement. For this one-third, it will be important to have some vocational skills that are saleable in the contemporary job market.

A second finding worth discussion deals with the difference between rural and urban parishes. Given the increasingly technical labor market in many rural areas, potential employees in these areas may become subjected to the same kinds of job requisites as employees in urban areas. While this is merely a hypothesis at this point, it is very reasonable to anticipate this shift in job requisites since many of the new agribusinesses have their origins in urban areas (e.g., Ralston-Purina in St. Louis) and in non-agriculturally related industries (e.g., urban banks investing in rural land holdings). Again it is merely a hypothesis, but with rapid social change occurring in rural areas, rural youth must be counseled to understand the long-term importance of attaining at least a high school diploma. The importance is more pertinent for its likelihood of making available a broader range of potential jobs to choose from rather than any kind of guarantee of earning significantly more income over the course of one's lifetime.

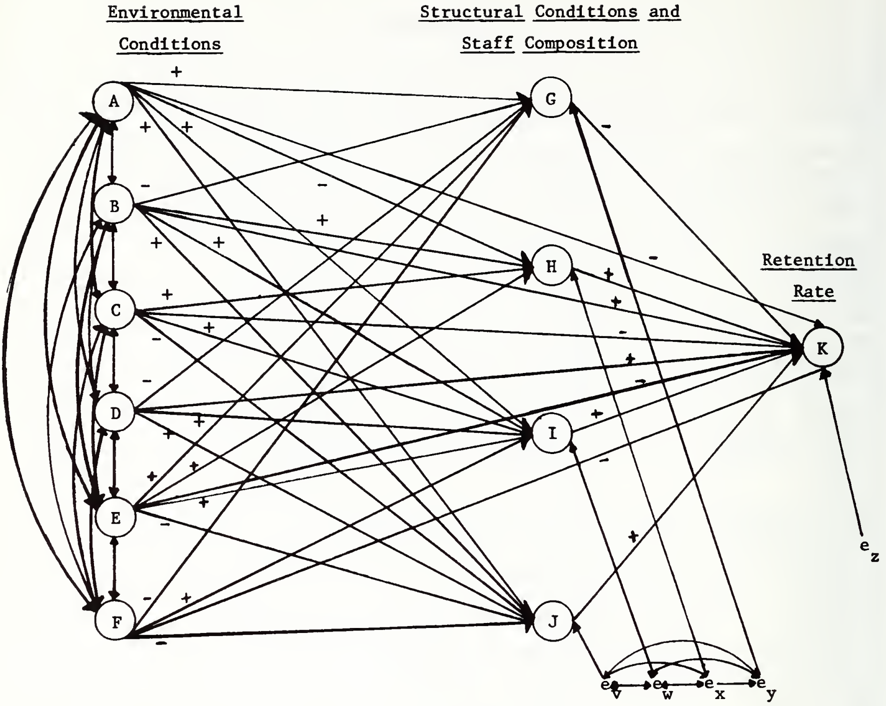
A final point worth mentioning is the general need to understand school district organizational effectiveness. Although our model explained only a small amount of the variance for retention, the substantive issue addressed by the model is still important—i.e., how well school districts succeed at attaining goals. In analyzing this goal attainment process, we can also come to better understand the complexity of the district as an organizational entity. It is via this type of analysis that we may get estimates on how much various organizational components contribute (or, fail to contribute) to organizational success. This has obvious policy implications. In our model we failed to show any significant effects from three of the four organizational variables. This suggests that if we wish to increase retention, our efforts will be best rewarded by increasing staff qualifications rather than by increasing administrators, or professional staff, or reducing pupil-teacher ratios.

Appendix

Table 4.—A listing of the most rural and most urban school districts in Louisiana in 1970

Most rural school districts	Percent rural	Most urban school districts[1]	Percent urban
Assumption	100.0	Bogalusa	100.0
Caldwell	100.0	Monroe	100.0
Cameron	100.0	Orleans	99.7
Grant	100.0	Jefferson	95.8
LaSalle	100.0	St. Bernard	91.3
Red River	100.0	East Baton Rouge	86.9
St. Helena	100.0	Caddo	85.5
Tensas	100.0	Ouachita	78.5
West Carroll	100.0	Calcasieu	74.8
West Feliciana	100.0	Lafayette	71.6
Sabine	83.3	St. Mary	65.2
Pointe Coupee	82.1	N = 11	
Bienville	81.5		
Livingston	81.5		
Union	81.5		
Franklin	77.7		
Catahoula	76.5		
Avoyelles	73.7		
East Feliciana	73.4		
St. Charles	72.8		
DeSoto	71.7		
Plaquemines	71.7		
Richland	68.5		
Jackson	68.2		
Ascension	68.0		
St. James	67.2		
Iberville	66.7		
N = 27			

[1] The independent school districts of Bogalusa and Monroe coincide with the geographical boundaries of those cities; all other districts are at the parish level.



The variables are: A = school district size; B = fiscal resources; C = disadvantaged children; D = parental education; E = rural population; F = nonwhite population; G = pupil-teacher ratio; H = administrative intensity; I = professional support component; J=qualifications of the staff; K = school district retention rate.

Figure 3.—A causal diagram of a model of school district organizational effectiveness for Louisiana.

Table 5.—Trends in the Louisiana retention rate

School session	Graduates	Public school 9th grade registration 3 years earlier[1]	Retention rate (%)
1975-76		72,748	
1974-75	47,691	72,255	66.0
1973-74	46,808	69,999	66.9
1972-73	45,704	68,744	66.5
1971-72	45,563	70,195	64.9
1970-71	44,446	--[2]	--[2]
1969-70	43,641	66,566	65.6
1968-69	43,883	64,114	68.4
1967-68	41,797	61,963	67.5
1966-67	40,503	61,078	66.3
1965-66	39,722	60,012	66.2
1964-65	39,269	58,275	67.4
1963-64	35,122	53,591	65.5
1962-63	28,823	47,294	60.9
1961-62	28,492	47,980	59.4
1960-61	27,543	46,641	59.1

[1] For example, graduates from 1974-75 are paired with 9th graders in 1971-72.

[2] Information not available.

Table 6.—Standard regression coefficients, coefficients of determination, and residuals for a model of school district organizational effectiveness (N = 66)

Predetermined variables[1]	Dependent variables[1]				
	G	H	I	J	K
A	.250	-.285*	-.206	-.100	.212
B	-.387***	.231**	.228	.277*	.017
C	-.057	.593***	.053	.023	-.296
D	.334*	.156	.034	.347	-.240
E	.305*	.164	.204	-.102	-.181
F	-.223	-.157	.060	.119	-.077
G					-.019
H					.213
I					-.039
J					.293*
R^2	.562	.642	.277	.178	.209
Residual	.662	.599	.850	.906	.943

[1] The variables are: A = school district size; B = fiscal resources; C = disadvantaged children; D = parental education level; E = rural population; F = nonwhite population; G = pupil-teacher ratio; H = administrative intensity; I = professional support component; J = qualifications of the staff; K = school district retention rate.

*, **, *** = significant differences at probabilities of 0.05, 0.01, and 0.001, respectively.

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Scaling Social Data Across Time:

A Comparison of Samples and Techniques

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Scaling Social Data Across Time: A Comparison of Samples and Techniques

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INTRODUCTION

Longitudinal survey research is characterized by its own peculiar problems. Changes in the social situation, as well as changes in methodological procedures, create problems for researchers trying to measure change through comparisons of responses at different time periods. Scale and index construction is one specific area of survey research that is particularly affected by these problems. The major focus of this publication is on some of the problems associated with use of scales and indexes across time periods and across subpopulations.

Data presented here were collected as parts of the S-79 Regional Research Project, "Quality of Life in the Rural South," and the S-44 Regional Research Project, "The Adjustment Potential of Families and Individuals of Low Income Rural Areas of the South." Research objectives of the S-79 project focused on changes that occurred between 1960 and 1972, as well as the status of quality of life in 1972, in selected southern counties that were designated as low-income in 1950. Part of the research design was longitudinal in that some of the household data collected in 1972 for the S-79 project were comparable to data collected in 1960 as part of the S-44 Regional Project. (See Appendix A for details of the sampling procedures).

The general objective of the 1960 project was to study the socioeconomic conditions of rural families and their attitudes toward their present situation and possible future changes. As part of the fulfillment of this objective, the S-44 project leaders developed and compared numerous scales and indexes which were published as a Southern Cooperative Series Bulletin (Cleland, 1965). The items in several of these indexes were judged to be valid indicators of quality of life by the S-79 project leaders and were, therefore, included in the S-79 project. The S-44 bulletin, *Scaling Social*

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Data: A Comparison of Scales Developed Using Various Techniques, was an edited publication with contributions from researchers at several experiment stations. In contrast, all scales and indexes included in the present bulletin were constructed at the Louisiana Experiment Station from data collected by project leaders from all the states at both time periods. Using current computer procedures, the scales and indexes for the 1960 data were reconstructed. The 1960 and 1972 data were pooled for scale and index construction, and scales and indexes were developed for three samples in the 1972 study. (See Appendix B for details of data compilation for this project). The 1972 study included two states not included in the original 1960 data set. In addition, some, but not all, state representatives drew total county samples. Therefore, the three major sample bases for the 1972 study were the original six-state, open-country sample; the eight-state total sample; and the eight-state, open-country sample. When available, data from each of the five samples were analyzed. For some data collected in 1972 there were no comparable data for the 1960 time period.

Objectives

The specific objectives of this report are to present a total set of possible scales and indexes from the S-44 and S-79 research project data. Comparisons will be made among these scales and indexes to demonstrate differences in results between subpopulations, as well as differences due to various procedures.

Problems in Constructing Scales and Indexes Across Time Periods

Several problems and issues become apparent when collecting and analyzing data for scales and indexes across time periods and populations. Guttman (1950:89) summarized, ''Scales are relative to time and to populations.'' Items that scale at one point in time may not necessarily scale at another point in time. At the same point in time, items may scale for a subpopulation but not for the total population. Therefore, for comparative analysis, scales and indexes must be limited to those items which apply at all time periods for the total sample under analysis. As noted previously, specific aspects of the S-79 research project have necessitated the development of scales and indexes for several subpopulations.

Some of the major problems arise during the construction and pretesting of the interview schedule for the later time period. Three specific problems are relevancy of the items, meaning of the items, and appropriateness of the current data analysis techniques to the responses. Questions asked at one time period may not be relevant or may have a different meaning at another time period. Other questions may be more relevant, but without comparable data no statistical analysis of change can be made. Therefore, the researcher interested in change is limited to the questions asked in the original study.

Another problem related to the schedule and future analyses is the appropriateness of response categories. Levels of measurement and techniques considered appropriate and desirable at one time period may be less acceptable at a later time. However, the researcher is limited to the level of measurement utilized in the previous study. This limitation was particularly frustrating in this project. For example, none of the scales used in 1960 had as many as five response categories.

A somewhat different problem that must be dealt with is that of obtaining comparable samples. The details of the study sample will be discussed in a separate section, but some general considerations related to obtaining comparable samples for longitudinal analysis need to be noted. The first and most obvious point is that the sample is limited to a comparable sample in the later time period. The sample size may be altered drastically by people moving out of the sampling area or by an area becoming heavily populated. Therefore, some type of sampling adjustments may have to be made to accommodate changing populations. Cooperative research projects have the potential for affecting the sample in another way. Representatives of a state involved at one time period may choose not to participate at a later date. The sample for that state has to be dropped unless other provisions for data collection can be made. In fact, one state that was represented in the S-44 project was not represented in the S-79 project.

Procedures for Constructing Scales and Indexes

The procedures utilized were judged to be the most appropriate for the types of data available. Guttman scalogram techniques were applied to the material possession items and the communication items because the data were dichotomous. Factor analyses were applied to the remaining sets of data for purposes of index construction.[2] Comparisons between various weighting procedures of factor analyzed items were made on selected sets of items. Indexes were prepared for the following sets of items: anomia, job satisfaction, satisfaction with county situations, and leisure time activities. Attempts at Guttman scales were unsuccessful for the anomia and job satisfaction items.

Guttman Scalogram Procedure

Guttman scalogram techniques have been widely used by social scientists to measure attitudes, as well as other attributes, which can be ordered along a continuum. Therefore, only a brief review of the procedure will be presented in this section. According to Guttman (1950:88),

> scale analysis tests the hypothesis that a group of people can be

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[2] Scale is used here for procedures that order both items and people. Index refers to procedures which do *not* order items.

> arranged in an internally meaningful rank order with respect to an area of qualitative data. A rank order of people is meaningful if, from the person's rank order, one knows precisely his responses to each of the questions or acts included in the scale.

As noted by Guttman (1950:89), "perfect scales are not found in practice." However, certain standards of acceptability have been recommended by Guttman and others. The most common criterion is the coefficient of reproducibility, which is the degree to which the scale approximates perfection. Scales with coefficients of reproducibility of .90 and above are generally considered acceptable (Guttman, 1950:89). Another criterion, coefficient of scalability, was developed by Menzel (1953) to correct for unusual extremes in items or individuals. He suggested a CS of .60 to .65 as a possible acceptable range. Proctor (1970 and 1971) derived procedures for determining the probability of misclassification of items, scale reliability, and flat reliability. Each of the procedures developed by Proctor and Menzel has strengthened the criterion proposed by Guttman for evaluation scales.

The Proctor-Guttman program in the Statistical Analysis System was used to construct scales attempted for this bulletin. (See Appendix C for the details of this procedure). This program was found to be quite stringent when compared to earlier procedures such as the Ford technique (1954). The print-out includes the scalogram correlation coefficients, the coefficient of reproducibility, the minimum marginal reproducibility, percent improvement, coefficient of scalability, marginal frequency, chi-square value (difference in predicted and observed patterns) and class score for each possible arrangement of items, the total chi-square, degrees of freedom, required probability of misclassification plus standard error, scale reliability, flat reliability plus standard error, and average score plus standard error. The program uses only dichotomous items.

Factor Analysis

The use of factor analysis in index construction is often found in current social science literature. However, the explicit procedure used is often unclear. While individual researchers, including the author, have used various procedures and compared the results to other types of scales, little research of this type has been published.[3] Principle component or unrotated factor analysis was used for determining the final items and weightings for all indexes presented in this bulletin.[4] This procedure is simply a means of determining the internal consistency of the items, and as such is a measure of reliability. The loadings on the factors in the unrotated matrix can be interpreted in the same manner as correlation coefficients. "The square of the loading multiplied by 100 equals the percent variation that a variable has in common with an unrotated pattern" (Rummel, 1967:463). The average for all the items in the factor yields the percent of total variation among the variables that is related to a factor pattern. Items with loadings of .4000 in the first unrotated factor were the ones retained in the final index. Some researchers use all the original items in a schedule and weight them by the factor loadings regardless of how low they may be. However, it seems that some cutting point is desirable. As stated by Likert in justifying his technique, "No matter for what *a priori* reasons the experimenter may consider a statement to belong in a scale, if the statement, when tried on a group, does not measure what the rest of the statements measure, there is no justification for keeping that statement in the battery" (1932:49). The cutting point of .4000 is an arbitrary one. Likert suggested that the size of the correlation coefficient required for inclusion of an item in a Likert scale is a function of the intended use (1932:49). He suggested that the figure needs to be higher if specialized aspects of attitudes are being studied than if their use is for a general survey type of study. Robinson, Rusk and Head (1969:17) pointed out that when all factor weightings are between .15 and .45, the factor structure seems indeterminate. Items which load at .4000 have 16 percent of their variance explained in a factor. A minimum average loading of .5000 or some other weight might also be used as a criterion for evaluating an index.

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[3] The two senior authors have obtained minimum correlations of .98+ between indexes constructed by the Likert technique and the factor analysis procedure described in this bulletin on various data sets since 1972. The Likert procedure used for these comparisons include determining Z scores for each item based on the frequency distribution, item analysis by the upper and lower quartiles of respondents' summated scores by T-tests, and summated scores by Z weightings of the retained items (Edwards, 1957:149-71).

[4] The authors are aware that the factor analysis procedure assumes interval level data. However, experience indicates that this assumption can be relaxed.

The means and standard deviations of items provide another useful criterion for determining which items should be retained. An unusually low or high mean and a relatively low standard deviation suggest that an item may not be a discriminating item and should therefore be eliminated even if the factor loading meets the minimum level. It should be noted that when a variable is removed from the set, the factor loadings for the remaining items will change. Therefore, it is necessary to submit the items to further factor analyses to be sure that the remaining items will produce an index when items are omitted. This is also a necessary step if the loadings are to be used to weight the responses. For example, if an item with a loading of .42 is highly correlated with a deleted item, then the retained item may not have a minimum of .40 on the next run. Likewise, an item loading at .38 may have a higher loading when an item with which it is not highly correlated is omitted. A review of the correlation matrix can help predict marginal items that will be retained or lost with the omission of specific items. The final index is one where each item is correlated with the set of remaining items at .40 or above on the first factor. Only the first factor is used because the largest pattern of relationships is delineated in this factor. In other words, this factor is the most comprehensive classification in the data. The amount of variation decreases successively with each factor (Rummel, 1967:463-65).

The items weighting high on the first unrotated factor may factor into two or more factors when rotated. This occurrence raises the old question of unidimensionality. If unidimensionality is a concern of the researcher, it seems that labeling can handle the problem. For example, in this study, the high loading leisure activity items on the first unrotated factor formed two conceptually distinct rotated factors: within neighborhood activities and away from neighborhood activities. We labeled the comprehensive pattern ''Total Leisure Index'' and subjected the specific items in the two rotated factors to separate principal component analyses for determining item weights for the specific types of activity indexes. A choice can be made from the three indexes depending on the nature of the analysis intended by a specific researcher on the S-79 project.

Whether to weight responses or not, and whether to standardize scores or not are other arbitrary decisions that have to be made when factor analysis is used to calculate index scores. Factor analysis may be used only to determine items to be retained in the final index. The original response scores can be summed for the total index score. Another approach is to weight the responses by the factor loading for each item and then sum these weighted responses for the total score.

Another arbitrary decision is in deciding whether to standardize scores or not. The data further can be manipulated by standardizing the scores to assure a normal distribution. The size of the sample is a major consideration when making this decision, because as with any other sampling distribution, chances of a skewed distribution increase as sample size decreases. Some researchers prefer standardized scores between a certain range, such as 0-100. These scores may be more easily interpreted than the raw scores; however, for large samples, little may be gained for the amount of effort expended. Items can be standardized by the following formula:

$$\frac{\text{raw score} - \text{mean score}}{\text{standard deviation}}$$

The standardized score may be weighted by the factor loading if weighting of items is preferred.

Results and Discussion

Results from the various analyses will be presented in this section for each of the scales and indexes attempted from all the data sets. Specific information related to the construction of each of the scales and indexes will be presented prior to the results for each set of data. Comparisons among various weighting techniques will be presented as the final section of this chapter.

Material Possessions Scales

Introduction: The material possession items included in this project were limited to items that were available in 1960. Items such as trash compactors and clothes dryers were automatically eliminated because they were not included in the 1960 list of items. Comparable data were available for a total of 16 items. The computer program described in the Procedure Section could handle only 13 items with a sample as large as the combined 1960-1972 data set; therefore, certain items were arbitrarily eliminated prior to the first run. These items were bath or shower, electricity, and electric sewing machine.

Results: Guttman scales for the material possession items are presented in Tables 1-5. The most notable finding, even though expected, was the tremendous increase in material possessions over the twelve year period. The same nine items were retained in all the scales. However, the items in positions 7 and 8 switched positions over the twelve year period. That is, more respondents owned central heat than owned air conditioning in 1960,

Table 1.—Material Possessions Scale and Relevant Statistics for Combined S-44—S-79 Sample

Scale Score	Item	N Scale Types	% Owning Item	Errors
9	Dishwasher	41	3	61
8	Air Conditioner	199	17	374
7	Central Heat	497	19	421
6	Vacuum Cleaner	518	39	446
5	Inside Flush Toilet	428	50	182
4	Hot Water Heater	266	51	238
3	Kitchen Sink	393	68	195
2	Gas or Electric Range	531	80	167
1	Mechanical Refrigerator	382	93	62
0		203		

N = 3458

Coefficient of Reproducibility	.9310
Minimum Marginal Reproducibility	.7380
Percent Improvement	.1930
Coefficient of Scalibility	.7368
Required Probability of Misclassification	.0469
Scale Reliability	.9545
Flat Reliability	.9440
Standard Error	.0018
Average Score	4.0836
Standard Error	.0441

and in 1972 a slightly larger percentage owned air conditioning than owned central heat. Percentages owning an inside flush toilet and hot water heaters also shifted over time; however, the differences were minor. The lowest coefficient of reproducibility obtained for the five scales was .92, and the lowest coefficient of scalability was .63. The average score increased from 2.97 in 1960 to 5.3 in 1972 for the six-state, open-country samples. Although ownership of most of the items increased dramatically and minor shifts occurred in the scale pattern, there seems to be adequate evidence that priorities for these household items remained rather stable over the 12 year time period.

Communication Scales

Introduction: Information regarding access to eight communication items were included in the interview schedules for both time periods. An attempt to construct a scale from only eight items is always risky and in this case it was impossible to obtain satisfactory scales for any of the samples.

Table 2.—Material Possessions Scale and Relevant Statistics for S-44 Six-States, Open-Country Sample

Scale Score	Item	N Scale Types	% Owning Item	Errors
9	Dishwasher	4	1	9
8	Air Conditioner	20	4	45
7	Central Heat	89	11	113
6	Vacuum Cleaner	176	24	191
5	Inside Flush Toilet	183	27	100
4	Hot Water Heater	146	30	126
3	Kitchen Sink	234	51	132
2	Gas or Electric Range	365	65	131
1	Mechanical Refrigerator	329	87	47
0		189		

N = 1735

Coefficient of Reproducibility	.9427
Minimum Marginal Reproducibility	.7865
Percent Improvement	.1563
Coefficient of Scalibility	.7319
Required Probability of Misclassification	.0393
Scale Reliability	.9586
Flat Reliability	.9537
Standard Error	.0022
Average Score	2.8733
Standard Error	.0529

Results: Coefficients of reproducibility are shown for eleven trials in Table 6. Major sources of error for both time periods were the daily and weekly newspapers. When the two were combined (see trial 9), the CR was not improved. Trial 8, without any newspaper had a CR of .90, but theoretically it is difficult to conceive of a communication index without a newspaper. The coefficient of scalability for this pattern was only .5811 and the flat reliability was only .8304. Therefore, for both theoretical and mathematical reasons this scale has to be labeled questionable.

As shown in Table 7, a major source of change between the two periods was the relationship of radio to television. In the 1972 data, more people (94 percent) owned TVs than radios (91 percent), whereas, in 1960 only 63 percent of the respondents had television and 82 percent had radios. The largest percentage change for an individual item was found for telephones. Ownership of telephones was sixth in rank in 1960 and third in 1972. This shift contributed to high error patterns for the combined time periods.

Table 3.—Material Possessions Scale and Relevant Statistics for S-79 Six-States, Open-Country Sample

Scale Score	Item	N Scale Types	% Owning Item	Errors
9	Dishwasher	37	6	53
8	Central Heat	179	27	286
7	Air Conditioner	408	30	273
6	Vacuum Cleaner	342	54	255
5	Hot Water Heater	245	72	61
4	Inside Flush Toilet	120	72	102
3	Kitchen Sink	160	85	64
2	Gas or Electric Range	169	95	37
1	Mechanical Refrigerator	55	99	17
0		14		

N = 1729

Coefficient of Reproducibility	.9262
Minimum Marginal Reproducibility	.7907
Percent Improvement	.1355
Coefficient of Scalibility	.6475
Required Probability of Misclassification	.0500
Scale Reliability	.9387
Flat Reliability	.9399
Standard Error	.0027
Average Score	5.3042
Standard Error	.0602

One has to conclude that communication items for these samples do not form adequate scales. Large increases in telephones and televisions and decreases in farm and trade magazines between the two time periods contributed to many of the error patterns across time. Newspapers accounted for another major source of error in that they did not seem to fit into an ordering of communication items at any time period.

Anomia Indexes

Introduction: A slight modification of the Srole (1956) anomia scale was included in the 1960 data set (Cleland, 1965); therefore, comparable data were collected in 1972. The modification consisted of the addition of one item, ''Things have usually gone against me in life.'' Anomia, as used in this research, refers to the sociopsychological state of an individual or his attitude (Moon and McCann, 1966:28).

Although Moon and McCann were able to obtain Guttman scales with the anomia items, using the Stone (1958) technique at the time the 1960

Table 4.—Material Possessions Scale and Relevant Statistics for S-79 Eight-States, Open-Country Sample

Scale Score	Item	N Scale Types	% Owning Item	Errors
9	Dishwasher	58	8	90
8	Central Heat	234	29	356
7	Air Conditioner	479	30	338
6	Vacuum Cleaner	411	54	289
5	Hot Water Heater	289	72	70
4	Inside Flush Toilet	135	73	113
3	Kitchen Sink	175	84	64
2	Gas or Electric Range	213	95	48
1	Mechanical Regrigerator	72	98	26
0		17		

N = 2083

Coefficient of Reproducibility	.9251
Minimum Marginal Reproducibility	.7882
Percent Improvement	.1369
Coefficient of Scalibility	.6464
Required Probability of Misclassification	.0509
Scale Reliability	.9396
Flat Reliability	.9386
Standard Error	.0024
Average Score	5.3407
Standard Error	.0575

data were analyzed, McCann (1975) was unable to duplicate these scales using the Proctor Guttman procedure which is available in the SAS computer package. Therefore, a factor analysis was conducted on these items. The response categories were agree=1; don't know=2; and disagree=3.

Results: The factor analysis response patterns for the two time periods varied for one of the items: "These days a person doesn't know on whom he can count." This item correlated above .67 with the remaining items for the three 1972 samples, but its factor loading was only .0239 with the 1960 data and .2334 with the combined 1960-1972 data. In 1960, the standard deviation for this item was 1.64, whereas, the standard deviations for all the other items were less than 1.00. The mean score was 1.72.

Only one factor was formed from each of the five data sets presented in this bulletin. That is, the mathematical results reported for the responses from these samples suggest that these items are related to each other even though a Guttman scale could not be obtained by the stringent Proctor

Table 5.—Material Possessions Scale and Relevant Statistics for S-79 Eight-States, Total Sample

Scale Score	Item	N Scale Types	% Owning Item	Errors
9	Dishwasher	106	9	119
8	Central Heat	337	33	464
7	Air Conditioner	607	33	435
6	Vacuum Cleaner	487	58	335
5	Hot Water Heater	343	76	75
4	Inside Flush Toilet	146	77	119
3	Kitchen Sink	177	87	78
2	Gas or Electric Range	214	96	51
1	Mechanical Refrigerator	73	99	26
0		17		

N = 2507

Coefficient of Reproducibility	.9246
Minimum Marginal Reproducibility	.7945
Percent Improvement	.1300
Coefficient of Scalibility	.6329
Required Probability of Misclassification	.0509
Scale Reliability	.9393
Flat Reliability	.9387
Standard Error	.0022
Average Score	5.6174
Standard Error	.0556

Table 6.—Alternative Guttman Scale Trials for Communication Items for Combined S-44—S-79 Sample

Scale Score	Trials											
	1	(Errors)	2	3	4	5	6	7	8	9	10	11
8	MW	(500)										
7	OM	(550)	MW									
6	DN	(714)	OM	OM	MW	MW						
5	WN	(697)	DN	DN	OM	OM	OM	MW	MW	MA		
4	FTM	(892)	WN	WN	DN	DN	DN	OM	OM	T	MW	
3	T	(778)	T	T	WN	T	T	DN	T	NP	OM	T
2	TV	(439)	TV	TV	TV	TV	TV	TV	TV	TV	TV	TV
1	RD	(366)	RD	RD	RD	RD	RD	RD	RD	RD	RD	RD
Coefficient of Reproducibility	.82		.84	.84	.85	.87	.87	.88	.90	.85	.90	.92

N = 3455

MW = Magazine for Women
OM = Other Magazines
DN = Daily Newspaper
WN = Weekly Newspaper
FTM = Farm and Trade Magazine
T = Telephone
TV = Television
RD = Radio
MA = Other Magazines + Magazines for Women
NP = Daily Newspaper + Weekly Newspaper

Table 7.—Percent of Respondents in 1960 and 1972 Who Owned Communication Items

Item	% Owning Item 1960 and 1972	% Owning Item 1960	% Owning Item 1972
Magazines for Women	18	12	24
Other Magazines	24	18	28
Daily Newspaper	31	29	32
Weekly Newspaper	33	29	34
Farm and Trade Magazine	38	41	37
Telephone	47	26	68
Television	79	63	94
Radio	86	82	91
N	3455	1731	1724

technique. The 1960 responses factored into two factors before the one item was dropped. The lowest mean factor loading for the indexes was .6317. Even though the items cannot be ordered in a reliable way, they can be considered to be measuring an underlying continuum of an attitude for the respondents included in this research.

Job Satisfaction Indexes

Introduction: Items included as measures of job satisfaction plagued the S-44 research committee in that no successful scales were achieved. However, the S-79 research committee decided that the concept was still worth considering as an indicator of life quality. Therefore, the same set of items were included in the 1972 study that were included in 1960. Again, in the current study, attempts to construct Guttman scales by the authors were futile. Therefore, factor analysis was attempted as a means of sorting out the items.

The sample sizes for these indexes were limited to people currently employed or employed within the last year. Another limitation was the

Table 8.—Anomia Index Items for Combined S-44—S-79 Sample; Factor Loadings, Means, and Standard Deviations

Item	Factor Loading	Mean[1]	Standard Deviation
LFT[2]	0.6116	1.9293	0.9807
LGW	0.7343	1.8254	0.9279
HFBCW	0.7003	2.0449	0.9393
LUWPC	0.6000	1.7128	0.8786
TGAIL	0.5931	2.4687	0.8531
Average	0.6478		
N = 4342			

[1] Agree = 1; Don't Know = 2; Disagree = 3

[2] LFT = "Nowadays a person has to live pretty much for today and let tomorrow take care of itself."
LGW = "In spite of what some people say, the lot of the average man is getting worse, not better."
HFBCW = "It's hardly fair to bring children into the world with the way things look for the future."
DKCO = "These days a person doesn't really know whom he can count on."
LUWPC = "There's little use writing to public officials because often they aren't really interested in the problems of the average man."
TGAIL = "Things have usually gone against me in life."

exclusion of cases with "not applicable" items. For example, self-employed persons were eliminated by the item, "the way the boss treats me". The sample is therefore limited to persons who are employed for salaries or wages. The response categories were dislike=1; don't know=2; and like=3.

Results: The results from the analyses of the job satisfaction items give some clues to the problems of working with these items (see Tables 13-17). A major problem is the generally high means of the items. For example, in the S-79 six-state, open-country sample, only two items out of ten had mean scores below 2.75 on a scale of 1 to 3. The high means and relatively low standard deviations suggest that this index will have little discriminatory power. The same pattern is true for all three of the S-79 data sets. There was more variance in the responses to the items in the S-44 data, but the discriminatory power of this index is still questionable.

Table 9.—-Anomia Index Items for S-44 Sample; Factor Loadings, Means, and Standard Deviations

Item	Factor Loading	Mean	Standard Deviation
LFT	0.6159	2.0272	0.9905
LGW	0.7400	1.8927	0.9469
HFBCW	0.7032	2.1017	0.9471
LUWPC	0.6005	1.7192	0.8993
TGAIL	0.6279	2.4235	0.8818
Average	0.6575		
N = 2536			

Table 10.—Anomia Index Items for S-79 Six-States, Open-Country Sample; Factor Loadings, Means, and Standard Deviations

Item	Factor Loading	Mean	Standard Deviation
LFT	0.5793	1.7754	0.9641
LGW	0.7060	1.7096	0.9067
HFBCW	0.6863	1.9451	0.9404
DKCO	0.6829	1.5237	0.8648
LUWPC	0.6389	1.6835	0.8646
TGAIL	0.5588	2.4948	0.8569
Average	0.6420		
N = 1839			

Perhaps the most valuable contribution of these indexes is the comparison between items which hold together in the two time periods. Six items (working conditions, amount of responsibility, importance of the job, chances to get ahead, money, and kind of work) were included in all five data sets. Steadiness of work and retirement benefits factored with these in the 1960 data set, but not in the 1972 data sets. However, the boss's treatment, people you work with, doing the same job everyday, and the working hours factored with the basic six items in the 1972 data, but they did not factor with the six items in the 1960 data. This finding suggests that job satisfaction was more generalized in 1972 than in 1960.

Leisure Participation Indexes

Introduction: Although leisure-time activities were not included in the 1960 data set, the S-79 research committee believed that leisure activities

Table 11.—Anomia Index Items for S-79 Eight-States, Open-Country Samples; Factor Loadings, Means, and Standard Deviations

Item	Factor Loading	Mean	Standard Deviation
LFT	0.5926	1.7746	0.9644
LGW	0.7164	1.7304	0.9147
HFBCW	0.6746	1.5173	0.8634
DKCO	0.6758	1.6811	0.8685
LUWPC	0.6488	2.4836	0.8621
TGAIL	0.5632	2.4836	0.8621
Average	0.6452		
N = 2196			

Table 12.—Anomia Index Items for S-79 Total Sample; Factor Loadings, Means, and Standard Deviations

Item	Factor Loading	Mean	Standard Deviation
LFT	0.5884	1.8310	0.9591
LGW	0.7122	1.8085	0.9146
HFBCW	0.6580	1.9919	0.9288
DKCO	0.6800	1.5554	0.8640
LUWPC	0.6219	1.7392	0.8721
TGAIL	0.5299	2.5461	0.8002
Average	0.6317		
N = 2580			

participation is a valid indicator of "quality of life". The leisure activity items differed in another way from the other indexes constructed for this project. A total leisure participation index with eight items was obtained from a principal component factor analysis. However, when rotated, the responses to these items formed two conceptually distinct factors: leisure time around the home and neighborhood, and leisure time away from home. Items in each of these rotated factors were subjected to separate principal component factors analyses for weightings. Three leisure indexes are presented for each of the S-79 samples.

Results: As shown in Tables 18-23, the items were the same for both the open-country and the total sample for each of the three sets of items. The factor weights were essentially the same for the two samples. Spectator

Table 13.—Job Satisfaction Index for Combined S-44—S-79 Sample

Item Description	Factor Loading	Mean[1]	Standard Deviation
The Steadiness of His Work During the Year	0.45583	2.66191	0.73669
Doing the Same Job Day after Day	0.49859	2.76400	0.62569
The Working Conditions	0.57451	2.76070	0.61825
The Amount of Responsibility Respondent Has	0.60081	2.78156	0.56988
The Importance of His or Her Job to Other People	0.63391	2.77387	0.54006
Hir (or Her) Chances of Getting Ahead	0.67718	2.16465	0.93486
The Retirement and Other Benefits	0.50909	2.12075	0.93804
The Amount of Money Earned	0.51406	2.13721	0.97657
The Kind of Work Respondent Does	0.59389	2.83754	0.53448
Average	0.56199		
N = 911			

[1] Dislikes = 1; Don't Know = 2; and Likes = 3

Table 14.—Job Satisfaction Index for S-44 Six-States, Open-Country Sample

Item Description	Factor Loading	Mean	Standard Deviation
The Steadiness of His Work During the Year	0.54898	2.57219	0.81466
The Working Conditions	0.52702	2.75401	0.63704
The Amount of Responsibility Respondent Has	0.56737	2.76471	0.60226
The Importance of His or Her Job to Other People	0.60526	2.74064	0.58084
His (or Her) Chances of Getting Ahead	0.71694	2.02139	0.96844
The Retirement and Other Benefits	0.62267	2.04011	0.94967
The Amount of Money Earned	0.49886	1.99198	0.99459
The Kind of Work Respondent Does	0.51686	2.79947	0.59479
Average	0.57550		
N = 374			

sports and participation sports were the highest loading items in the Total Leisure Index even though all the items loaded above a .470 (see Tables 18 and 19). Only one item was deleted from the total set included in the questionnaire: informal social activities. The mean factor loading for this index was 0.5795.

Factor loadings for the Home and Neighborhood Leisure Participation Index items are shown in Tables 20 and 21. The means and standard deviations are the same as shown in Tables 18 and 19. The weightings for all three items are high and quite similar within and between the samples. As could be expected, the Away from Neighborhood Leisure Participation Index items also weighted high (see Tables 22 and 23). Although each of

Table 15.—Job Satisfaction Index for S-79 Six-States, Open-Country Sample

Item Description	Factor Loading	Mean	Standard Deviation
The Number of Hours Respondent Must Work	0.42809	2.75225	0.64927
Doing the Same Job Day after Day	0.53665	2.79730	0.57753
The Way the Boss Treats Him (or Her)	0.50284	2.79730	0.56966
The Working Conditions	0.66064	2.77477	0.60747
The Amount of Responsibility Responsibility Has	0.62860	2.79054	0.54900
The Importance of His or Her Job to Other People	0.65294	2.79505	0.50806
His (or Her) Chances of Getting Ahead	0.56460	2.29955	0.88524
The Amount of Money Earned	0.44230	2.26351	0.94567
The Kind of Work Respondent Does	0.69175	2.86486	0.48427
The People Respondent Works with on the Job	0.49099	2.89414	0.39758
Average	0.55994		
N = 444			

Table 16.—Job Satisfaction Index for S-79 Eight-States, Open-Country Sample

Item Description	Factor Loading	Mean	Standard Deviation
The Number of Hours Respondent Must Work	0.43223	2.75641	0.64196
Doing the Same Job Day after Day	0.53640	2.73810	0.64045
The Way the Boss Treats Him (or Her)	0.52619	2.78205	0.57957
The Working Conditions	0.65538	2.74359	0.64410
The Amount of Responsibility Respondent Has	0.62893	2.75092	0.59988
The Importance of His or Her Job to Other People	0.61627	2.78388	0.51491
His (or Her) Chances of Getting Ahead	0.56311	2.26740	0.89130
The Amount of Money Earned	0.45658	2.25275	0.94928
The Kind of Work Respondent Does	0.69172	2.83150	0.53243
The People Respondent Works with on the Job	0.44145	2.89927	0.39133
Average	0.55483		
N = 546			

the leisure activity items presented here did correlate highly with the total set of items, there were two conceptually and mathematically distinctive categories.

Table 17.—Job Satisfaction Index for S-79 Eight-States, Total Sample

Item Description	Factor Loading	Mean	Standard Deviation
Doing the Same Job Day after Day	0.53410	2.73977	0.64447
The Way the Boss Treats Him (or Her)	0.54808	2.79386	0.57004
The Working Conditions	0.64156	2.76170	0.62659
The Amount of Responsibility Respondent Has	0.62160	2.77778	0.57552
The Importance of His or Her Job to Other People	0.59545	2.81140	0.48502
His (or Her) Chances of Getting Ahead	0.55285	2.29240	0.89042
The Amount of Money Earned	0.44674	2.28216	0.94237
The Kind of Work Respondent Does	0.68755	2.85819	0.49187
The People Respondent Works with on the Job	0.45563	2.90789	0.37724
Average	0.56484		
N = 684			

Table 18.—Total Leisure Participation Index for S-79 Eight-States, Open-Country Sample; Factor Loadings, Means, and Standard Deviations

Item	Factor Loading	Mean[1]	Standard Deviation
Hunting and Fishing[2]	0.6557	1.6826	1.5436
Camping and Boating	0.6253	0.5601	1.1548
Inside Activities	0.4726	3.0515	1.1611
Outside Activities Around House	0.4853	2.1398	1.5519
Participant Sports	0.6992	0.6289	1.2165
Spectator Events	0.7211	1.0917	1.4749
Neighborhood and Community Activities	0.4952	1.5709	1.5422
Formal Associations	0.4815	0.3680	1.0018
Average	0.5795		
N = 2196			

[1] Never = 0; Seldom = 1; Occasionally = 2; Fairly Often = 3 and Very Often = 4

[2] See Appendix for complete description of items.

Table 19.—Total Leisure Participation Index for S-79 Eight-States, Total Sample; Factor Loadings, Means, and Standard Deviations

Item	Factor Loading	Mean	Standard Deviation
Hunting and Fishing	0.6410	1.6771	1.5408
Camping and Boating	0.6225	0.5986	1.1851
Inside Activities	0.4781	3.0963	1.1257
Outside Activities Around House	0.4761	2.1108	1.5635
Participation Sports	0.7128	0.7285	1.3013
Spectator Events	0.7307	1.1815	1.5152
Neighborhood and Community Activities	0.5062	1.6393	1.5519
Formal Associations	0.4834	0.4476	1.0941
Average	0.5813		
N = 2626			

Table 20.—Within Neighborhood Leisure Participation Index for S-79 Eight-States, Open-Country Sample; Factor Loadings, Means, and Standard Deviations

Item	Factor Loading	Mean	Standard Deviation
Inside Activities	0.7278	3.0515	1.1611
Outside Activities Around House	0.7177	2.1398	1.5519
Neighborhood and Community Activities	0.6342	1.5709	1.5422
Average	0.6932		
N = 2196			

Table 21.—Within Neighborhood Leisure Participation Index for S-79 Eight-States, Total Sample; Factor Loadings, Means, and Standard Deviations

Item	Factor Loading	Mean	Standard Deviation
Inside Activities	0.7272	3.0963	1.1257
Outside Activities Around House	0.7044	2.1108	1.5635
Neighborhood and Community Activities	0.6353	1.6393	1.5519
Average	0.6890		
N = 2626			

Rating of County Situations Indexes

Introduction: As with the leisure items, the rating of county situation items in 1972 did not have comparable data for the 1960 sample. The 1972 interview schedule included 20 items related to situations in the respondents' counties. These items included ratings of situations for specific groups of people, as well as for services and facilities. The response categories were very good=1; pretty good=2; fair=3; and poor=4.

Results: The results for the open-country and total samples were quite similar in that the same ten items were retained in each index and the weightings were essentially the same for the two samples (see Tables 24 and 25). The mean factor loading was approximately .60 for each of the indexes.

The "job situation" and "salaries and income" were the two highest weighting items on these indexes. "Public utilities" and "physical environment" were the lowest loading items retained in the index. Items which

Table 22.—Away from Neighborhood Leisure Participation Index for S-79 Eight-States, Open-Country Sample; Factor Loadings, Means, and Standard Deviations

Item	Factor Loading	Mean	Standard Deviation
Hunting and Fishing	0.6802	1.6826	1.5436
Camping and Boating	0.6971	0.5601	1.1548
Participant Sports	0.7464	0.6289	1.2165
Spectator Events	0.7345	1.0917	1.4749
Formal Associations	0.5202	0.3680	1.0019
Average	0.6757		
N = 2196			

Table 23.—Away from Neighborhood Leisure Participation Index for S-79 Eight-States, Total Sample; Factor Loadings, Means, and Standard Deviations

Item	Factor Loading	Mean	Standard Deviation
Hunting and Fishing	0.6667	1.6771	1.5408
Camping and Boating	0.6928	0.5986	1.1851
Participant Sports	0.7570	0.7285	1.3013
Spectator Events	0.7466	1.1815	1.5152
Formal Associations	0.5147	0.4476	1.0941
Average	0.6756		
N = 2626			

did not correlate at .4000 with the total set of items were county government, politics, public schools, agriculture, medical and health services, welfare law, real income, religion, and recreation facilities.

Comparisons of Various Item Weighting Procedures

As noted in the procedure section, the questions of whether or not to weight and standardize scores often arise when indexes are being constructed. In an attempt to determine how different weighting systems would affect the scores, two sets of index items were scored by three

Table 24.—Satisfaction with County Situation for S-79 Eight-States, Open-Country Sample; Factor Loadings, Means, and Standard Deviations

Item	Factor Loading	Mean	Standard Deviation
Educational Opportunities beyond HS	0.5913	1.8885	0.8485
Roads and Transportation	0.5406	2.1869	0.9423
Salaries and Income	0.7028	2.1049	0.8317
Job Situation	0.7388	2.2639	0.9814
Public Utilities	0.4424	2.1082	0.9051
Physical Environment	0.4366	2.2918	0.9116
Housing	0.6480	2.1197	0.8936
Situation for Young People	0.6254	2.3508	0.9967
Situation for Old People	0.5999	2.4115	0.9824
Situation for Blacks	0.6663	1.9393	0.8829
Average	0.5992		
N = 610			

Table 25.—Satisfaction with County Situation for S-79 Eight-States, Total Sample; Factor Loadings, Means, and Standard Deviations

Item	Factor Loading	Mean	Standard Deviation
Educational Opportunities beyond HS	0.5550	1.8711	0.8405
Roads and Transportation	0.5305	2.2242	0.9487
Salaries and Income	0.7005	2.1168	0.8335
Job Situation	0.7190	2.3262	0.9931
Public Utilities	0.4563	2.0926	0.8910
Physical Environment	0.4390	2.2926	0.9145
Housing	0.6514	2.1128	0.8969
Situation for Young People	0.6422	2.4188	1.0103
Situation for Old People	0.6082	2.4403	0.9752
Situation for Blacks	0.6613	1.9517	0.8678
Average	0.5963		
N = 745			

Table 26.—Correlations and Other Relevant Statistics for Three Procedures for Scoring Anomia Index Items for S-79 Eight-States, Open-Country Sample

	Correlation Coefficients	
	B	C
A[1]	0.998644 0.0001	0.998616 0.0001
B		0.999621 0.0001

N	Sum	Mean	Min Value	Max Value	Standard Deviation
A 2154	24266.00000000	11.26555246	6.00000000	18.00000000	3.32509383
B 2154	15146.71889600	7.03190292	3.79003400	11.37010200	2.12069913
C 2154	0.00000000	0.00000000	-3.69872127	4.89839543	2.39492273

[1] A = Summated Scores of Items Weighting over .4000 on Principal Component FA
B = Items Weighted by Factor Loadings and Summed
C = B Standardized

different procedures: simple summated scores, factor-loading weighted summated scores, and standardized weighted scores. These procedures were applied to items that loaded at .4000 or above on the first unrotated factor. Correlations and other relevant statistics are presented in Table 26 for the Anomia items for the S-79 open-country, eight-state sample. Similar statistics were derived for the Total Leisure Index. The correlations for the three procedures were astonishingly high for both indexes. The lowest correlation of .9947 was between the simple summated scores and the standardized weighted scores for the Total Leisure Index.[5] Due to the extremely high correlations, similar comparisons were not made on the other indexes. These findings reveal that simple summated scores are equivalent to weighted and standardized scores for these items and samples.

Experience in working with these data sets and others of more limited scope from previous studies leads to the conclusion that the use of principal component factor analysis is an efficient and reliable means of determining which items to retain in an index. Simple summation of response weights of the retained items seems to give index scores comparable to more complicated weighted and standardized scores for these samples. The large sample size probably contributes to the high correlations between the weighted and weighted standardized scores. However, the similarities to the unweighted scores cannot be explained by sample size.

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[5] A Likert index was also constructed on the total set of Leisure items. The correlation coefficient for scores from the factor analysis and from the Likert procedure was 0.968.

APPENDIX A

Sampling Methodology of S-44 and S-79

With the initiation of the S-79 Regional Project, the major objective was to assess changes in citizens' views on the quality of life in open-country areas of the South from 1960 to 1972. So that comparative data analyses could be conducted, the sampling procedures of S-79 were based on the sampling procedures of S-44. However, objectives specific to S-79 (e.g. assessing citizens' views in non-open country areas) and changes in the nature of the sample population (e.g. open-country population size had changed) dictated the need to institute certain modifications in the original sampling procedures of S-44. Consequently, the discussion to follow initially focuses on a detailed description of the original S-44 methodology and subsequently focuses on the procedures that were implemented for S-79.

Sampling Methodology of S-44

The major objective of S-44 was to survey a sample of families for citizens' views on the quality of life in the rural South. The discussion of the sampling procedures of S-44 is presented in two stages. The first stage is a general overview of the sample design, the intended goals, and the overall results. The second stage is a detailed description of the sample survey including (1) the definition of the universe, (2) the frame, (3) the method of collecting data, and (4) the sample design.

Overview. Seven states participated in S-44 (Alabama, Kentucky, Louisiana, Mississippi, North Carolina, Tennessee, and Texas). The sample of families from each state was selected on a random area basis following a two-stage stratified random sample design. The first stage was to stratify the counties in each state according to five State and General Area types. From each stratum, two counties were selected through sampling with replacement. The second stage was to partition each sample county into open-country area segments. Each area segment was expected to yield one sampling unit, that is, a collection of eight households. The sample counties (primary sampling units) and the number of area segments sampled from each county at the second stage (secondary sampling units) were selected so that the entire sample would be self-weighting, that is, weighted according to the open-country population in each county.

The delineation of the area segments and the sampling units therein was carried out by members of the Statistical Department of North Carolina State University at Raleigh. The delineation of the area segments and corresponding sampling units was based on master sample materials from the 1950 U.S. Census and county maps. The actual field work, that is, locating the area segments selected and interviewing the families therein, was carried out by the representatives from the individual states.

The goal of the sampling methodology was to obtain usable interview schedules from a sample of approximately 2500 households. However, since the delineation of the area segments and corresponding sampling units was based on master sample materials that were somewhat out of date (e.g. population loss in rural areas from 1950 to 1960 when the data were collected), the counties were purposely oversampled to yield approximately 3000 households. The outcome was usable schedules from 1953 households, selected from 30 counties in the seven states with an average of 12.6 area segments per county.

Detailed description. The discussion to follow describes in detail all components of the S-44 sampling methodology.

A. *Definition of universe.*—The universe consisted of all counties in the seven states (Alabama, Kentucky, Louisiana, Mississippi, North Carolina, Tennessee, and Texas) and all households therein that had certain characteristics.

1. Eligible counties were those that had, for each of five State and General Area types, farm-operator level-of-living indexes in 1950 which did not exceed 75. The five State and General Area types were Appalachian Mountains and Border (Area 1), Southern Piedmont and Coastal Plains (Area 2), Southeastern Hilly (Area 3), Mississippi Delta (Area 4), and Sandy Coastal Plains (Area 5).[1] The farm-operator level-of-living index for each county reflects the "average level of current consumption or utilization of goods and services" by farms in that county (e.g. percentage of farms with electricity, with telephones, or with automobiles).[2] For each state and for each State and General Area type, the eligible counties are listed in Appendix D.

2. Eligible households were those that resided in the open-country portion of the counties. Open-country was defined as all areas that were not large enough to be classified as a village (population of 250 or more).

B. *Frame.* County maps, showing the occupied dwelling units and area topographic features, and Master Sample materials of 1950 constituted the frame. The frame was used to identify the strata, the counties, and the area segments. Each area segment was expected to yield one sampling unit (eight households) based on the county maps and master sample materials.

C. *Method of collecting data.* Researchers from the individual states carried out the actual field work. The method was personal visitation and interviewing of the households in the selected area segments.

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[1] For description of the five "State and General Area" types, refer to *Factors Related to Levels of Living of Rural Households in Low-Income Areas of the South,* Southern Cooperative Series Bulletin 142, December, 1968.

[2] For discussion of farm-operator level-of-living indexes, refer to *Farm Operator Level of Living Indexes for Counties of the United States,* United States Department of Agriculture Marketing Service, Washington, D.C., Statistical Bulletin No. 204, March, 1957.

D. *Sample design.* For each state, all eligible geographically contiguous counties were stratified according to the five types of "State and General Areas." A stratum was not to consist of more than 20 geographically contiguous counties. If a stratum had more than 20 counties, then it was divided into two strata such that each stratum had roughly the same open-country population based on 1950 census data. The final result was 16 strata for the seven states (Appendix D).

For each stratum, the sampling was conducted in two stages. Two counties (primary sampling units) from each stratum were selected in the first stage, sampling with replacement. The probability of selecting a county was proportional to the open-country population in the county based on 1950 census data. The determination of the selection probabilities is presented shortly.

The final result of the first stage sampling was 30 counties selected from the 16 strata (see Appendix D). The selected counties are denoted by "X." If a county was selected twice due to sampling with replacement, then the county is denoted by "XX."

For the second stage, the number of area segments (secondary sampling units) to be selected at random from each sample county was determined so that the entire sample would be self-weighting. If a county was selected twice, then the selection of the prescribed number of area segments from the county was carried out again, after replacing the first set of area segments. Since each area segment was expected to yield eight qualifying households, and since the counties were to be oversampled to yield approximately 3000 households, 375 area segments (i.e. 3000/8 = 375) had to be selected at the second stage.

The determination of the selection probabilities for counties and the number of area segments to be selected from each county is described below.

Let N_i = number of eligible counties in the i^{th} stratum

$i = 1, 2, \dots, 16$

N_{ij} = total number of area segments in the j^{th} county of the i^{th} stratum

$j = 1, 2, \dots, N_i$

Y_i = total number of persons in the open-country of the i^{th} stratum based on 1950 census

Y_{ij} = total number of persons in the open-country of the j^{th} county of the i^{th} stratum

Now, in the first stage, the probability of selecting a county from each stratum was to be proportional to the open-country population in the county.

P_{ij} = probability of selecting the j^{th} county in the i^{th} stratum

$$= \frac{Y_{ij}}{Y_i} \text{ where } \sum_{j=1}^{N_i} P_{ij} = 1.$$

The estimated open-country population for each county, stratum, and state is presented in Appendix D. As an example, the probability of selecting Houston county ($Y_{11} = 20{,}894$) from the first stratum of Alabama ($Y_1 = 236{,}338$) is given by $P_{11} = 20{,}894/236{,}338 = 0.0884$.

In the second stage, the number of area segments to be selected from each county was to be determined so that the entire sample would be self-weighting. To determine the number of area segments to be selected from each county, suppose the true total characteristic of the population is to be estimated (e.g. total number of people employed).

Let x_{ijk} = total characteristic of all qualifying households in the k^{th} area segment of the j^{th} county in the i^{th} stratum

T = true total characteristic for the population

$$= \sum_{i=1}^{16} \sum_{j=1}^{N_i} \sum_{k=1}^{N_{ij}} x_{ijk}$$

An unbiased estimate of T given two counties per stratum is

$$\hat{T} = \sum_{i=1}^{16} \sum_{j=1}^{2} \left(\frac{1}{2}\right)\left(\frac{1}{P_{ij}}\right)\left(\frac{N_{ij}}{n_{ij}}\right) \sum_{k=1}^{n_{ij}} x_{ijk}$$

where n_{ij} = number of area segments to be selected from the j^{th} county in the i^{th} stratum

The goal was to select a total of 375 area segments where the number of area segments to be selected from each county (n_{ij}) was to be determined so that the entire sample would be self-weighting, that is, n_{ij} was to be selected such that

$$(1) \quad \sum_{i=1}^{16} \sum_{j=1}^{2} n_{ij} = 375$$

$$(2) \quad \left(\frac{1}{2}\right)\left(\frac{1}{P_{ij}}\right)\left(\frac{N_{ij}}{n_{ij}}\right) = c = \text{constant for all strata (16) and all counties in each strata (2)}$$

The determination of n_{ij} is described below.

From (2), multiply through by n_{ij} and $\frac{1}{c}$

$$(3) \quad N_{ij} = \left(\frac{1}{2c}\right)\left(\frac{N_{ij}}{P_{ij}}\right)$$

From (1), substitute (3)

$$(4) \quad 375 = \left(\frac{1}{2c}\right) \sum_{i=1}^{16} \sum_{j=1}^{2} \frac{N_{ij}}{P_{ij}}$$

From (3), solve for 2c and substitute into (4)

$$(5) \quad 2c = \frac{N_{ij}}{(P_{ij}) \quad (n_{ij})}$$

$$(6) \quad 375 = \frac{(P_{ij})\,(n_{ij})}{N_{ij}} \sum_{i=1}^{16} \sum_{j=1}^{2} \frac{N_{ij}}{P_{ij}}$$

From (6), solve for n_{ij}

$$(7) \quad n_{ij} = (375)\left(\frac{\frac{N_{ij}}{P_{ij}}}{\sum_{i=1}^{16} \sum_{j=1}^{2} \frac{N_{ij}}{P_{ij}}}\right) \quad \text{where} \quad \sum_{i=1}^{16} \sum_{j=1}^{2} n_{ij} = 375$$

Since N_{ij} is actually unknown in practice, (7) needs to be re-written in terms of quantities that are known, namely Y_i and Y_{ij}. To do so, an assumption is made, namely, the number of persons per occupied dwelling unit in the open-country is constant from county to county and from stratum to stratum in a particular state. The population per occupied dwelling unit, denoted $(POP/ODU)_i$, is given below each state in Table 28.

Now, all area segments (N_{ij}) are expected to yield approximately eight households each. The open-country population in each county (Y_{ij}) is known, and the population per occupied dwelling unit, $(POP/ODU)_i$, is known on the basis of the 1950 census.

Therefore,

$$(8)\quad N_{ij} = \text{total number of area segments for a particular county} = \frac{Y_{ij}}{8 \cdot (POP/ODU)_i}$$

$$(9)\quad P_{ij} = \frac{Y_{ij}}{Y_i}$$

$$(10)\quad \frac{N_{ij}}{P_{ij}} = \frac{Y_i}{8 \cdot (POP/ODU)_i}$$

From (7), substitute (10)

$$(11)\quad n_{ij} = 375 \cdot \frac{\dfrac{Y_i}{8 \cdot (POP/ODU)_i}}{\sum_{i=1}^{16} \sum_{j=1}^{2} \dfrac{Y_i}{8 \cdot (POP/ODU)_i}}$$

The determination of n_{ij} by equation (11) for all counties is summarized in Table 28. The total number of area segments was 378 due to rounding-off the calculated n_{ij}'s.

E. *Sample delineation and specification.* Each county was partitioned into area segments where the delineation of the area segments was ideally to meet two criteria. First and foremost, each area segment was to contain one sampling unit, based on the county maps showing the occupied dwelling units. Eight households were to constitute each area segment.

Secondly, from practical considerations in carrying out the field work, each area segment was to be well demarcated by easily identifiable landmarks and boundaries so that the households therein could be readily located in the field. Ideally, the use of imaginary lines in demarcating area segments was avoided whenever possible. If imaginary lines had to be used to meet the second criteria, then the imaginary lines were anchored by easily identifiable landmarks, such as a bridge or road intersection.

In delineating the area segments, both criteria could not always be met. Sometimes the boundaries of an area segment via identifiable landmarks or imaginary lines included more than one sampling unit. Once delineated, the area segments were marked in red on the county maps and numbered consecutively from one to the total number of area segments in the county. In addition, the sampling units were numbered consecutively, but since an area segment may have contained more than one sampling unit, more than one number, corresponding to the sampling unit, may have been assigned to an area segment.

The prescribed number of sampling units (n_{ij}) was selected at random from each county. The area segments corresponding to the selected sampling units were the sample areas where interviewing was to be conducted. Each sample area was given a numerical specification which defined the procedures to be followed in selecting the households to be interviewed. As an example, a numerical specification may have been 2 - 5 - 2/2. The first number specified the sample county in the state where the counties were numbered consecutively from one to the total number of sample counties in that state. The second number specified the sample area (marked in red) within the sample county (e.g. sample area 5 in county 2).

The third number specified the number of sampling units assigned to the sample area and the sub-sampling procedures to be applied in selecting the households therein. The ''denominator'' indicated the number of sampling units contained in the sample area (e.g. sample area 5 was assigned 2 sampling units). As indicated previously, the goal was to have only one sampling unit per area segment, that is, a denominator equal to one.

The implied fraction in the third number indicates the sub-sampling rate to be applied. For example, the sub-sampling rate for sample area 5 in county 2 was 1/2 where the numerator indicates the first household in the sample area to be interviewed. For example, 2/2 indicated to interview every second household in the sample area starting with the second household.

The procedure for implementing the intervewing process was to start at some predetermined point in the sample area, such as the northeast corner, and moving in a clockwise direction around the area, number each household shown on the county map. Then, according to the sampling rate (e.g. 2/2), interview every second household starting with the second household until the sample area is exhausted, that is, implement a 1-in-2 systematic sample. The starting point and ordering process used by the interviewer in numbering the occupied dwelling units in a sample area was arbitrary, but was to be consistent from one sample area to another within the same county.

Under certain conditions, the procedures as described above were modified. First, if movement into a designated sample area revealed that the number of eligible households in the area was substantially more than expected, then the sampling rate was adjusted by the interviewer to obtain the eight households per area. If the area yielded substantially less than the anticipated eight households (e.g. excessive call backs or refusals), then an alternate area segment was selected at random to meet the expected sample size (see Table 29 which gives final results of the S-44 survey). Call backs were to be made at least twice, on different days and at different hours.

Secondly, since more than one sampling unit may have been selected in a given area or since a sampling unit may have been selected twice in a given area, the sampling rate may have been adjusted to yield the anticipated number of qualifying households. A sampling unit could have been selected twice in a county since the counties were selected in the first stage based on sampling with replacement. For example, if a sample area had two sampling units assigned and the sample area was represented by the selection of two sampling units, then the sampling rate was modified from 1/2 to 1/1 to yield 16 households.

Finally, if an area segment had only one sampling unit and the sampling unit was selected twice, then an alternate segment was selected to yield the prescribed number of sampling units for a county.

Sampling Methodology of S-79

The major objective of S-79 was to assess changes in citizens' views on the quality of life in open-country areas of the South. A second objective was to survey a sample of families for citizens' views on the quality of life in non-open-country areas of the South. However, the drawing of a total sample (open- and non-open-country) was encouraged, but not required, for the eight participating states (Alabama, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee).

Except for Georgia and South Carolina, which did not participate in S-44, the sampling plan for the S-79 states was to be essentially the same as the methodology used in S-44. Georgia and South Carolina implemented a different methodology. Consequently, the methodology of the six S-44 states is discussed prior to describing the methodology followed by Georgia and South Carolina.

Summarizing the outcome of the S-79 sample survey, 31 counties were sampled from the eight states. A non-open-country sample was obtained in 13 of the 31 counties. The final sample was composed of 2627 households (2202 open-country and 425 non-open-country). The number of households (open- and non-open) for each state and sample county is presented in Table 30.

Methodology for Six States. The plan was to follow the same methodology of S-44, that is, the same counties and area segments of S-44 were to be re-sampled using the same county maps. However, certain rules, modifications, and restrictions were to be implemented in drawing the sample.

1. The minimum open-country sample size for each S-79 county was to fall between the obtained and expected sample size for S-44 (see Table 29). Open-country was defined as in S-44, that is, no areas large enough to be classified as a village (250 or more persons).

2. If the original area segments did not yield the number of eligible households needed to meet the minimum sample size, then additional segments were to be selected at random based on the S-44 county maps. If the number of eligible households in an original segment or newly selected segment exceeded the number of households expected (i.e. eight households per segment), then the sampling rate was to be adjusted as in S-44 to yield approximately eight households. Finally, if 10 percent or more of the eligible households that were selected for interviewing in a county were not interviewed due to refusals, excessive call backs, or the like, then additional segments were to be selected to meet the minimum sample size requirement. At least two call backs were to be attempted, on different days and at different hours, before a household was to be dropped from the sample.

3. Although not required, if a non-open-country sample was selected in a county, then the expected non-open-country sample size for a county was to be proportional to the open-country sample size based on 1970 census data. The expected sample size for a non-open-country county sample was to be determined as follows.

$$\frac{\text{Expected N (1950 open-country)}}{\text{1970 open-country population}} = \frac{\text{Expected N (non-open-)}}{\text{1970 non-open-country pop.}}$$

The number of area segments needed to yield the expected non-open-country sample size (eight households per segment) was to be delineated and selected by the individual researchers using the S-44 county maps. The households were to be selected following the rules described in Part 2 above.

The plan as described above could not be ideally implemented by all states. First, Montgomery county in Alabama which was sampled in S-44 had become entirely urbanized. Fayette county was selected as a replacement (see Appendix D) and was sampled based on the same procedures that were used in selecting and sampling Montgomery county.

The loss in open-country population extended to other sample counties where the minimum open-country sample size requirements could not be met. Finally, the original S-44 county maps were unavailable for Louisiana. As a result, using current county maps, the same counties were sampled, but a new set of area segments were delineated and selected at random.

Methodology for Georgia and South Carolina. From the counties that would have been eligible in S-44 (see Table 31), three counties were selected from each state as stipulated for S-44, that is, proportional to the open-country population based on 1950 census data. However, each state constituted only one stratum, and three counties, rather than two, were selected (denoted "X" in Table 31).

The procedural steps that were used for delineating, selecting, and sampling area segments are given below. An early reference from the literature for this sampling methodology is J. A. King, "The Master Sample of Agriculture." *Journal of American Statistical Association,* Vol. 40 (March, 1945), 38-56.

Specific references for S-79 needs are: the mimeographed document by Chuck Cleland titled "Sample Design For Regional Rural Sociology Project S-44," and the July, 1972, Memorandum from Glen McCann, and the materials accompanying that memorandum.

Following is an explanation of the sampling procedures utilized in South Carolina, based on the three references above.

A. Steps for selecting and delineating area segments. The selection process for Jasper County, South Carolina is depicted in Table 27 and is used as an example in the following steps.

1. Obtain a print-out of housing units by Enumeration District (E.D.) [1970 Census of Population and Housing] for each study county.
2. Tabulate the housing units by E.D.
3. Cumulate the housing units through all E.D.'s in the county (C.H.U.)
4. Cumulate ten percent of the units through all E.D.'s [C(.10)]
5. Obtain E.D. maps and cultural maps for the sample counties. In most states, State Highway Departments have prepared the cultural maps and the Bureau of the Census has superimposed E.D.'s on these maps.
6. Utilizing information from Step 3, plot "segments" of ten households each on the E.D.-cultural maps.
7. Number the segments using the N.W. Ordinance Survey system of numbering.
8. From Step 4 calculate ten percent of this cumulative sum (37, in the example from the table).
9. Select, randomly, *five* numbers in this range (0-37, from Step 8).
10. Record these five numbers on the appropriate line (E.D.1) in the E.D. - housing units table. These five columns are labeled "V", "W", "X", "Y", and "Z" in the table.
11. Add 37 (ten percent of the cumulative sum, from Steps 8, 9, and 10) to each of these five base numbers and place in appropriate

lines and columns; repeat this process through all E.D.'s. The number recorded in each line must be in the appropriate range: i.e., not greater than the C (.10) number on that line and not less than the C (.10) number in the preceeding line.

12. These numbers represent the random sample of segments (from the numbered maps, Step 7) in which interviewing is to be conducted.

B. Steps for sampling the selected area segments.

1. The lines (on the table) for Enumeration Districts "2" and "8" are tentatively marked out; these are the two incorporated places in the county. However, *all* enumeration districts in the county are to be included in the sampling process, so that a total-county sample of segments will be available, if interviewing is to be conducted in the non-open-country categories.
2. Initial interviewing is to be conducted only in the Enumeration Districts with five sample segments listed on the table. These may be termed "segment units."
3. The remaining segments (in Enumeration Districts "5", "7", "9", "12", and "13") constitute a sub-set of alternate segments to be utilized if eight respondents cannot be interviewed in one or more of the segment units. For example, if the interviewer found (and interviewed) only one occupied household in each of the "V", "W", "X", and "Z" segments for a given segment unit, he would go to the first segment listed on an incomplete E.D. line (in this case, segment 152). If it was necessary to repeat this process, the interview would go to segment 206, and so on.
4. The segments listed in column "V" are the "prime" sample segments; i.e., interviewers should first attempt to obtain eight respondents from each "V" segment (if five sample segments are listed for that enumeration district).
5. If the interviewer actually found 16 occupied (lived in) households in that segment, he would attempt to obtain respondents from every other household (geographically) in the segment.
6. If the interviewer found (and interviewed) four occupied households in the prime segment, he would go to the first alternate segment (in column "W"). Perhaps he found (and interviewed) two occupied households in that segment; he would then go to the second alternate segment (in column "X"), in an attempt to complete his eight-respondent requirement. See Step 3 for the methods to follow in case a segment unit does not yield eight respondents.
7. Regarding selection of alternate segments for interviewing, each segment has equal likelihood of being selected, and the combination of prime and alternate segments are representative of the county's population.

APPENDIX B

Preparation of Data for Analyses

The analytical construction and comparison of the scales and indexes for 1960 data (S-44), 1972 data (S-79), and combined 1960-1972 data required the creation of a master data bank (card files and tape files). The master data bank was to include all data collected by the states that participated in the S-44 and/or S-79 Regional Projects.[1] A second goal was to make available to each state a tape record of all data collected. The objective was to make possible analyses of the combined data for all states using the master tape and analyses of data desired by the individual states using their own respective tapes.

The focus of the process for creating the master data bank was to determine and rectify any inaccuracies encountered in transferring the collected data to card and tape media. The process followed two general steps: (1) creation of the master card files, and (2) translation of the master card files to master tape files. Each file was classified according to the type of data included, for example, S-44 household data and census data. A brief description of the master tape files is given subsequent to a discussion of the procedures that were followed in creation of the master data bank.

Master Card Files

Each state followed a common format for the coding of S-44 and S-79 data. A codebook that specified the format for coding each type of data was available to each state. Each state had the coded data punched on IBM cards. Copies of these cards were sent to the Department of Experimental Statistics, Louisiana State University at Baton Rouge, for processing. These data constituted the master card files.

Prior to creating the master tape files, only S-79 data were checked for any inaccuracies in the card files since S-44 data had been collected, processed, and analyzed prior to the S-79 Regional Project (rf. *Scaling Social Data,* Southern Cooperative Series Bulletin No. 108, December, 1965).

The punched S-79 data were transferred to a tape for processing. For each state, frequency distributions for all items in the data were printed. The frequency distributions were checked against the codebook specifications for any errors in the punched data. If errors were found, they were noted on the frequency distributions. In addition, a printout was obtained that identified the error(s) for each item and the card(s) containing the errors. The Statistical Analysis System (SAS) was used to obtain all printouts.

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[1] The states involved in the process for data preparation were Alabama, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee. Only Georgia and South Carolina did not participate in the S-44 Regional Project.

Each state was sent the information that identified the errors in the data from that state. Each state documented the needed corrections and sent the documented corrections to Louisiana State University where the corrections were made in the master card files. Throughout the processing of S-79 data, the master card files were updated for any additional incoming data from the states. The individual state card files were maintained and updated by the state.

Master Tape Files

Following the initial phase of updating the master card files, the data were translated to a master tape. Also, each state in the S-79 Project received a copy of the master data tape. Analyses by the individual states uncovered additional errors in the data. The corrections were sent to Louisiana State University where the master card and tape files were updated. The individual state master tapes were updated either by the state or by Louisiana State University.

Description of Tape Files

The master data tape (T2149) included six source data set files and two SAS72 data set files. A brief description of each file, including computer parameter specifications and the information contained in each file, is given below. The parameter specifications included are the data set name (DSN), variable format (FMT), logical record length (LRECL), block size (BLKSIZE), and the number of blocks (BLOCKS).

File 1 (DSN = S79. HOUSEHLD.DATA,FMT = FB,LRECL = 80,BLKSIZE = 7280,BLOCKS = 116). The information includes for each respondent in S-79 demographic data, responses to items used in scale and index development, and the attitudes and behaviors of respondents regarding "quality of life" indicators, such as occupation, income, and education.

File 2 (DSN = S79.SPECIAL.CARD5,FMT = FB,LRECL = 80,BLKSIZE = 7280,BLOCKS = 29). The information includes for each respondent in S-79 answers to open-ended questions regarding attitudes and behaviors relative to a variety of social areas, such as social organizations, living conditions, and education.

File 3 (DSN = S79.CENSUS.DATA, FMT = FB,LRECL = 80,BLKSIZE = 7280,BLOCKS = 4). The information includes the census data relevant to both the S-44 and S-79 Regional Projects.

File 4 (DSN = S79.KNOWLDGE.DATA, FMT = FB,LRECL = 80,BLKSIZE = 7280,BLOCKS = 5). The information includes the responses of 40 individuals from each sample county who were considered to be knowledgeable about the "quality of life" in the sample county. The questions were open-ended concerning a variety of areas, such as health, education, welfare, and politics.

File 5 (DSN = S44.HOUSEHLD.DATA,FMT = FB,LRECL = 80,BLKSIZE = 7280,BLOCKS = 86). The information includes all household data that was collected in the S-44 Regional Project.

File 6 (DSN = S79.CARD7.DATA,FMT = FB, LRECL = 80,BLKSIZE= 7280,BLOCKS = 28). The information includes for each respondent in S-79 answers to open-ended questions regarding "reasons for not moving or for moving."

File 7 (DSN = S79.HOUSEHLD.INDX, FMT = VB, LRECL = 2044,BLKSIZE = 2048,BLOCKS = 2628). A SAS72 data set (S79IDX) was created for analysis purposes only. The data set included all S-79 household data plus the indexes from several scales, such as anomia, material possessions, and leisure participation.[2]

File 8 (DSN = S44.HOUSEHLD.INDX, FMT = VB,LRECL = 2044,BLKSIZE = 2048,BLOCKS = 1956). A SAS72 data set (S44IDX) was created including all S-44 household data plus the indexes from two material possessions scales.

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[2] All information concerning the two SAS data sets can be obtained from the Department of Experimental Statistics of Louisiana State University at Baton Rouge. The codebooks specify the data contained in each source data file.

APPENDIX C

Guttman Scale Analysis

The Material Possessions scales and Communication scales were developed using the Guttman procedure of the Statistical Analysis System (SAS), 1972 version. Nine items were included in Material Possessions scale development (Tables 1-5) and eight items were included in Communication scale development (Table 6). Scale development was based only on respondents who gave 0,1 responses to all items included in each scale where a 0 designated non-possession of an item and a 1 designated possession of an item.

The major objective of the discussion to follow is to analytically define the statistical output of the SAS Guttman procedure. For explanatory purposes, an example of a Guttman scale analysis is given in Appendix C. The example was reproduced from *A User's Guide to SAS 76* (Barr, et.al., 1976), except that four communication items were referenced for relevance: radio (RADIO), television (TV), telephone (TELE), and weekly newspaper (NEWS).

The output is discussed in three general stages. The first stage deals with the scalogram and statistics associated with the modified Goodenough technique for Guttman scale analysis (Edwards, 1957). Prior to the analytical definition of the statistical output (e.g. coefficient of reproducibility), the basic terminology of the definitions is briefly developed.

The second and third stages deal with Proctor's probabilistic formulation of a Guttman scale model (Proctor, 1970; 1971). The second stage deals with the method for assigning class scores to the observed response patterns. The third stage deals with the statistics associated with Proctor's formulation, for example, chi-square goodness-of-fit test statistic and scale reliability.

Modified Goodenough Technique

The fundamental question of a Guttman scale analysis is: To what extent do the observed response patterns, that is, the item 0,1 responses to an ordered set of items, such as (1 0 1 0) to (NEWS,TELE,TV,RADIO), conform to a true Guttman scale? The answer is based on the analytical definition of "true type patterns" and "non-scale or error patterns."

The initial step in defining true type patterns is to sequence the items in ascending order of item "marginal frequencies." The marginal frequency of an item is simply the frequency of respondents who possess that item. From the example (Appendix E), the item sequence for all patterns is (NEWS,TELE,TV,RADIO) with associated marginal frequencies of 24, 34, 53, and 69.

Once the items are ordered, the true type patterns and non-scale patterns are set. The true type patterns become T_0 = (0000), T_1 = (0001), T_2 = (0011), T_3 = (0111), and T_4 = (1111). All remaining non-scale patterns are error patterns, that is, patterns failing to conform to any true type pattern, such as (1010).

Now, the essential feature of an ideal Guttman scale, that is, all observed patterns are true type patterns, is that if the scale score assigned to each pattern is simply the sum of item 0,1 responses, then knowledge of the scale score alone allows for errorless prediction of the item 0,1 responses by a respondent. However, as in the example, ideal Guttman scales are rarely, if ever, found. Consequently, by grouping together all response patterns with the same scale score, the number of errors that would be made in predicting the items 0,1 responses of the respondents receiving a particular scale score can be determined.

The determination is made by comparing each error pattern with the true type pattern having the same scale score. For example, the error pattern (0 1 0 1) fails to conform to the true type pattern (0 0 1 1). Based on the scale score of 2 and the true type pattern (0 0 1 1), two errors would be made in predicting the items possessed by a respondent who specified (0 1 0 1) to (NEWS, TELE,TV,RADIO). The respondent is said not to possess newspaper service when in actuality he did possess one and is said to possess a radio when in actuality he does not.

Since seven respondents specified (0 1 0 1), two prediction errors would be made per respondent, and a total of 14 prediction errors would be made based simply on the knowledge of the scale score and the corresponding true type. In lieu of non-scale patterns, item 0,1 response patterns are said not to be ''reproducible'' based on knowledge of scale scores.

Having defined true type patterns, non-scale patterns, scale scores, and prediction errors, the output of the modified Goodenough technique can be analytically defined.

Scalogram. The scalogram is composed of ''item cells'' and ''marginal cells.''

1. Item cells provide the following information:

(a) for each scale score, the frequency of item 0,1 responses in all patterns with that scale score (e.g. 19 response patterns had a scale score of 3 where 11 respondents did not possess newspaper service and eight respondents did)

(b) for each scale score, the frequency of item 0,1 responses in error, denoted by an asterisk (e.g. the eight possession responses for newspaper service failed to conform to the true type (0 1 1 1) that predicts newspaper service is not possessed based on the scale score of 3).

2. Marginal cells provide the following information:

(a) the frequency of response patterns for each scale score (e.g. 31 respondents possessed only one item)

(b) the total frequency of response patterns (e.g. 111 respondents constituted the sample)

(c) the total frequency of item 0,1 responses (e.g. 77 respondents did not possess a telephone and 34 respondents did)

(d) the percentage of item 0,1 responses where the response with the highest percentage is the "modal response category" (e.g. 69% of the respondents did not possess a telephone, the modal response category, and 31% did)

(e) the total frequency of item 0,1 responses in error (e.g. seven respondents are predicted to possess a telephone when in actuality they did not possess one, and 14 respondents are predicted not to possess a telephone when in actuality they did)

(f) the total frequency of responses in error (e.g. 70).

Coefficient of reproducibility (CR). The coefficient of reproducibility measures the degree to which the response patterns are predictable based on knowledge of the scale scores. The coefficient is equal to the proportion of all predictions that are not in error.

Let K = total number of items (e.g. K = 4)
N = total number of respondents in the sample (e.g. N = 111)
F_e = total frequency of responses in error (e.g. F_e = 70)

$$CR = 1 - \frac{F_e}{K \cdot N} \quad \text{(e.g. CR = 0.8423)}$$

Minimum marginal reproducibility (MMR). The minimum marginal reproducibility is the coefficient of reproducibility that would be produced by predicting that every respondent gave the "modal response pattern" composed of the "modal response categories."

Let P_i = the proportion of respondents who gave the modal response category for the i^{th} item where i = 1, 2, . . . , K (e.g. the modal response pattern is (0 0 0 1) where $P_1 = 0.78$, $P_2 = 0.69$, $P_3 = 0.52$, and $P_4 = 0.63$)

$$MMR = \sum_{i=1}^{K} \frac{P_i}{K} \quad \text{(e.g. MMR = 0.6554)}$$

Thus, if every respondent was said to possess only a radio, that is (0 0 0 1), then a total of 153 errors would be made and the CR would be equal to 0.6554.

Percent improvement (PI). Percent improvement measures how much the predictions based on knowledge of the scale scores are improved over the predictions based on the modal response pattern.

$$PI = CR - MMR \quad \text{(e.g. PI = 0.1869)}$$

Coefficient of scalability (CS). The coefficient of scalability is the ratio of the percent improvement to the proportion of errors that would be made based on the modal response pattern.

$$CS = \frac{PI}{1 - MMR} \qquad (\text{e.g. } CS = 0.5425)$$

Correlation coefficients. The sample Pearson Product Moment interclass correlations are produced for all pairs of items and each item with the scale scores minus that item. For example, the correlation between NEWS and RADIO is 0.0939 and the correlation between RADIO and the scale scores without RADIO included is 0.2260.

Assignment of Class Scores

The score (index) that is assigned to a respondent with a particular response pattern is based on Proctor's probabilistic formulation of a Guttman scale model (Proctor, 1970). The underlying rationale for a probabilistic formulation is to standardize the method for assigning scores to observed response patterns and to provide statistical criteria of the "adequacy" of the method, such as reliability and tests of goodness-of-fit.

The fundamental assumption of the formulation is that every respondent belongs to one true Guttman type even though a non-scale pattern occurs. The supposition is that if a non-scale pattern occurs, then a "response error process" has intervened between the underlying true type and the respondent's stipulation of item possession.

Given the respondent does actually belong to one true Guttman type, but has a non-scale pattern, the basic question becomes, "What is the probability of a non-scale pattern, given the respondent belongs to a particular true type?" The idea is to determine that true type which maximizes the "posterior probability" of the non-scale pattern (Proctor, 1971). The scale score associated with the maximizing true type is the score assigned to the non-scale pattern. Parenthetically, the score for a true type pattern is simply the scale score, that is, the maximizing true type is the true type itself.

The specification of the conditional probability involves two parameters, the misclassification parameter (alpha, "a") and the true proportion of the given true type (theta, "Θ"). The misclassification parameter is the probability of stipulating that an item 0,1 response is in error, that is, fails to conform to the item 0,1 response of the given true type, when in fact the response is not in error. The misclassification parameter is assumed to be constant for all items.

The conditional probability, that is the probability of any response pattern given a particular true type, is given in equation (1) and the probability model, that is the probability of any response pattern, is given in equation (2).

$$(1)\ \Pr(X_i \mid T_l) = a^{D_{il}} (1-a)^{K-D_{il}} \Theta_l$$

$$(2)\ \Pr(X_i) = \pi_i = \sum_{l=1}^{K+1} \Pr(X_i \mid T_l) = \sum_{l=1}^{K+1} a^{D_{il}} (1-a)^{K-D_{il}} \Theta_l$$

Where K = number of items (e.g. $K = 4$)
a = misclassifiaction parameter, the probability of incorrectly predicting an item 0,1 response
$1 - a$ = the probability of correctly predicting an item 0,1 response
X_i = the i^{th} response pattern, e.g., $X_1 = (0000)$ and $X_6 = (0101)$
$i = 1, 2, \ldots, I$
$I = 2^K$ = total number of possible response patterns (e.g. $I = 16$)
T_l = the l^{th} true type pattern
$l = 1, 2, \ldots, K+1$
$K+1$ = total number of true type patterns, e.g. $K+1 = 5$, where $T_1 = (0000)$, $T_2 = (0001)$, $T_3 = (0011)$, $T_4 = (0111)$, and $T_5 = (1111)$
Θ_l = true proportion of the l^{th} true type in the population
D_{il} = the number of item 0,1 responses that must be changed to modify the l^{th} true type to match the i^{th} response pattern with the probability of making an incorrect change equal to "a," e.g. 1 response must be changed to match $T_4 = (0111)$ and $X_6 = (0101)$
$K - D_{il}$ = the number of item 0,1 responses that do not need to be changed to modify the l^{th} true type to match the i^{th} response pattern with the probability of correct classification equal to "1 – a," e.g. 3 responses do not need changing to match $T_4 = (0111)$ and $X_6 = (0101)$

As an example, the probability of $X_6 = (0\ 1\ 0\ 1)$ is given by

$$\begin{aligned}\Pr(X_6) &= \Pr(X_6 \mid T_1) + \Pr(X_6 \mid T_2) + \Pr(X_6 \mid T_3) + \Pr(X_6 \mid T_4) + \\ &\quad \Pr(X_6 \mid T_5) \\ &= a^2 (1-a)^2 \Theta_1 + a (1-a)^3 \Theta_2 + a^2 (1-a)^2 \Theta_3 + \\ &\quad a (1-a)^3 \Theta_4 + a^2 (1-a)^2 \Theta_5\end{aligned}$$

The score assigned is the scale score associated with that true type which maximizes the "posterior probability" of the response pattern.

Let x_i = score assigned to the i^{th} response pattern

t_l = scale score of l^{th} true type pattern

$$x_i = t_l : \max_{T_l} \Pr(X_i \mid T_l)$$

Naturally, the parameters are unknown, but maximum likelihood estimates of the parameters (Θ^*_l and a^*) are obtained using "Fisher's method of scoring" (Proctor, 1971; Rao, 1965). The SAS Guttman procedure produces the maximum likelihood estimates of (1) the misclassification parameter, called the "required probability of misclassification" (e.g. $a^* = 0.16$) and (2) the true proportion of the true types (e.g. Θ_1^*, Θ_2^*, Θ_3^*, Θ_4^*, and Θ_5^* are 0.30391, 0.26400, 0.18431, 0.14955, and 0.09832, respectively). Having the maximum likelihood estimates, the conditional probability, equation (1), and the probability model, equation (2), become

$$(1)\ \Pr^*(X_i \mid T_l) = a^{*\,D_{il}}(1-a^*)^{K-D_{il}}\,\Theta^*_l$$

$$(2)\ \pi_i^* = \sum_{l=1}^{K+1} a^{*\,D_{il}}(1-a^*)^{K-D_{il}}\,\Theta_l^*$$

Statistics Associated with Proctor's Formulation

The formulation of the probability model allows for the development of statistical criteria of the characteristics of the scale, in particular, (1) the chi-square test of goodness-of-fit, (2) scale reliability, (3) flat reliability, (4) the average score, and (5) the standard errors of estimates. Each of these measures is defined below.

Chi-square test of goodness-of-fit. The chi-square test is used to test the null hypothesis that the observed frequency of response patterns equals the expected frequency of the response patterns as specified by the probability model.

Let N = total frequency of response patterns (e.g. $N = 111$)

N_i = frequency of the i^{th} response pattern (e.g. $N_1 = 23$)

π_i^* = estimated probability of the i^{th} response pattern

$$X^2 = \frac{N \sum_{i=1}^{I} \left(\frac{N_i}{N} - \pi_i^* \right)^2}{\pi_i^*} \qquad \text{with I — K — 2 d.f.}$$

Scale reliability (SR*). Scale reliability is the square of the estimated correlation between the assigned scores, x_i , and the true type scores, t_l

$$\text{By definition, } \operatorname{Cov}(xt) = E(xt) - E(x) \cdot E(t)$$
$$\operatorname{Var}(x) = E(x^2) - E^2(x)$$
$$\operatorname{Var}(t) = E(t^2) - E^2(t)$$

By estimates,

$$\operatorname{Cov}^*(xt) = \sum_{i=1}^{I} \sum_{l=1}^{K+1} x_i\, t_l\, \Pr{}^*(X_i \mid T_l) - \Big(\sum_{i=1}^{I} x_i\, \pi_i^*\Big)\Big(\sum_{l=1}^{K+1} t_l\, \Theta_l^*\Big)$$

$$\operatorname{Var}^*(x) = \sum_{i=1}^{I} x_i^2\, \pi_i^* - \Big(\sum_{i=1}^{I} x_i\, \pi_i^*\Big)^2$$

$$\operatorname{Var}^*(t) = \sum_{l=1}^{K+1} t_l^2\, \Theta_l^* - \Big(\sum_{l=1}^{K+1} t_l\, \Theta_l^*\Big)^2$$

$$\text{Therefore, } SR^* = R^{*2} = \frac{\operatorname{Cov}^{*2}(xt)}{\operatorname{Var}^*(x) \cdot \operatorname{Var}^*(t)}$$

Flat reliability (FR*). Flat reliability is the square of the estimated correlation between the assigned scores and true type scores where the distribution of true type patterns in the population is assumed to be uniform. The derivation of flat reliability is described in Proctor (1971).

$$\text{By assumption, } \Theta_l = \frac{1}{K+1} \text{ for all } T_l$$

$$FR^* = \frac{(1 - 2a^*)^2}{1 - 4\,a^*(1 - a^*)\,\dfrac{K-1}{K+2}}$$

Average score. The average score is the estimated mean of the true type scores.

$$\text{By definition, } E(t) = \sum_{l=1}^{K+1} t_l\, \Theta_l$$

Therefore, average score = $\sum_{l=1}^{K+1} t_l \, \Theta_l^*$

Standard errors. The standard errors of all parameter estimates (Θ_l^* and a*), flat reliability, and the average score are produced. For example, the standard errors of Θ_1^*, Θ_2^*, Θ_3^* Θ_4^*, Θ_5^*, a*, FR*, and the average score are 0.06282, 0.07319, 0.06761, 0.06006, 0.04435, 0.00254, 0.0646, and 0.1916, respectively.

A complete definition of the standard errors are beyond the scope of the present report. All standard errors are based on "Fisher's method of scoring" which produces N times the estimated variance-covariance matrix of parameter estimates, called the "information (single observation) matrix." The method redefines the model where

$$a^* = \frac{1}{B^*} = \text{inverse of BETA}^* \ (\text{e.g. } a^* = 1/6.25088 = 0.16)$$

$$\Theta^*_{K+1} = 1 - \sum_{l=1}^{K} \Theta_l^* \ (\text{e.g. } \Theta_5^* = 0.09823)$$

Now, the estimated variance-covariance matrix for Θ_l^* where l = 1, 2, . . . , K and B* is determined by dividing the "information (single observation) matrix" by N. The estimated variance of Θ^*_{K+1} which is not produced can be determined by finding the variance of the linear combination, $1 - \sum_{l=1}^{K} \Theta_l^*$, and the estimated variance of a* can be determined as $1/B^{*2} \cdot \mathrm{Var}^*(B^*)$, described in Proctor (1970). Finally, by rewriting the average score as equal to $K - \sum_{l=1}^{K} (K - l + 1)\, \Theta_l^*$, the variance of the average score can be determined by finding the variance of the linear combination that defines the average score.

The standard errors of all estimates are then found by simply finding the square root of the variances. Finally, the standard error of FR* is given by Proctor (1971) as

$$S.E._{F.R.^*} = \frac{12(1 - 2a^*)\ S.E.(a^*)}{(K + 2) \cdot \left(1 - 4a^*(1 - a^*)\dfrac{K-1}{K+2}\right)^2}$$

APPENDIX D

Identification of Strata and Selected Counties

State	Stratum	General Area	County	Open Country Population	
Alabama	I	2	Houston	20,894	
			Covington	21,407	
			Escambia	17,097	
			Monroe	20,499	X
			Conecuh	17,291	
			Butler	19,404	
			Crenshaw	14,260	
			Coffee	19,129	
			Henry	13,763	
			Barbour	18,830	
			Russell	15,796	
			Randolf	16,027	
			Tallapoosa	21,941	X
			Total	236,338	
	II	3	Macon	20,636	
			Bullock	12,278	
			Montgomery	32,440	X
			Lowndes	16,660	
			Clarke	18,701	X
			Washington	14,396	
			Choctaw	16,840	
			Sumter	18,836	
			Marengo	21,816	
			Wilcox	21,475	
			Dallas	33,014	
			Perry	15,819	
			Hale	16,663	
			Greene	13,966	
			Pickens	18,376	
			Fayette	14,966	
			Winston	13,805	
			Jackson	29,343	
			Total	350,030	
			Grand Total	586,368	

State	Stratum	General Area	County	Open Country Population	
Kentucky	III	1	Cumberland	8,031	
			Clinton	8,685	
			Wayne	13,541	
			McCreary	16,660	
			Whitley	22,452	X
			Knox	25,879	
			Bell	27,752	
			Harlan	34,479	X
			Letcher	26,852	
			Pike	66,961	
			Floyd	42,431	
			Total	293,723	
	IV	1	Knott	18,466	
			Perry	31,593	X
			Leslie	14,890	
			Clay	21,410	
			Owsley	7,159	
			Jackson	13,101	
			Rockcastle	11,633	
			Estill	10,439	
			Lee	7,697	
			Wolfe	6,800	X
			Breathitt	17,986	
			Magoffin	12,665	
			Johnson	18,441	
			Morgan	12,693	
			Rowan	9,606	
			Elliott	6,847	
			Lawrence	12,403	
			Total	233,829	
			Grand Total	527,552	

State	Stratum	General Area	County	Open Country Population	
Louisiana	V	2	Washington	17,695	
			St. Helena	8,590	
			Livingston	17,501	X
			East Feliciana	10,274	X
			West Feliciana	9,233	
			Total	63,293	
	VI	4	St. Landry	49,565	
			Evangeline	21,170	
			Avoyelles	23,753	
			Concordia	8,253	
			Franklin	24,414	X
			Catahoula	9,336	
			Natchitoches	26,381	X
			Red River	10,325	
			Morehouse	17,148	
			West Carroll	15,144	
			Total	205,489	
	VII	5	Union	14,358	XX
			DeSoto	17,902	
			Bienville	13,676	
			Winn	9,773	
			Caldwell	7,573	
			Grant	10,764	
			Sabine	16,239	
			Total	90,285	
		Grand Total		359,067	

State	Stratum	General Area	County	Open Country Population	
Mississippi	VIII	3	Benton	8,120	
			Marshall	20,817	
			Tate	14,747	
			Yalobusha	10,561	
			Calhoun	13,624	
			Chickasaw	14,442	
			Clay	11,325	X
			Oktibbeha	16,587	
			Noxubee	16,248	
			Winston	16,334	
			Choctaw	8,728	
			Attala	18,643	
			Holmes	24,406	X
			Yazoo	25,059	
			Madison	23,295	
			Leake	18,815	
			Total	261,751	
	IX	3	Neshoba	21,139	X
			Kemper	14,206	
			Newton	16,232	
			Hinds	37,189	
			Claiborne	8,769	
			Copiah	21,457	
			Simpson	17,532	
			Smith	14,502	
			Jasper	16,047	
			Clarke	10,861	
			Wayne	13,350	
			Jefferson Davis	13,952	
			Lawrence	10,559	X
			Jefferson	9,808	
			Adams	9,516	
			Wilkinson	10,167	
			Amite	16,274	
			Total	261,560	
	X	4	Tunica	20,310	X
			Coahoma	30,291	X
			Quitman	21,974	
			Tallahatchie	25,416	
			Leflore	31,366	
			Sharkey	10,683	
			Total	140,340	
			Grand Total	663,651	

State	Stratum	General Area	County	Open Country Population	
North Carolina	XI	1	Ashe	20,476	XX
			Watauga	14,685	
			Avery	11,680	
			Mitchell	12,435	
			Yancy	14,965	
			Madison	17,414	
			Swain	8,422	
			Graham	6,371	
			Cherokee	14,314	
			Clay	5,650	
			Macon	13,684	
			Total	140,096	
	XII	2	Polk	8,609	
			Anson	20,152	X
			Scotland	17,451	
			Robeson	64,513	X
			Hoke	13,592	
			Cumberland	55,778	
			Bladen	26,400	
			Columbus	38,914	
			Brunswick	16,782	
			New Hanover	14,587	
			Pender	16,294	
			Duplin	33,054	
			Onslow	31,866	
			Total	357,992	
			Grand Total	498,088	

State	Stratum	General Area	County	Open Country Population	
Tennessee	XIII	1	Stewart	9,175	
			Clay	7,560	
			Overton	15,037	
			Pickett	4,714	
			Fentress	12,802	
			Morgan	15,009	
			Scott	16,058	
			Union	8,670	X
			Claiborne	24,385	
			Hancock	9,116	X
			Johnson	10,873	
			Unicoi	9,626	
			Grainger	13,086	
			Cumberland	16,434	
			Total	172,545	
	XIV	1	White	11,905	
			Putnam	19,312	
			Houston	4,460	X
			Humphreys	8,428	X
			Perry	5,608	
			Warren	14,170	
			Van Buren	3,264	
			Bledsoe	7,679	
			Cocke	18,984	
			Sevier	20,454	
			Sequatchie	4,812	
			Grundy	9,977	
			Lawrence	22,670	
			Lewis	4,375	
			Wayne	11,310	
			Total	167,408	
		Grand Total		339,953	

State	Stratum	General Area	County	Open Country Population	
Texas	XV	5	Bowie	23,840	
			Red River	15,023	
			Franklin	4,446	
			Titus	9,724	
			Morris	5,684	
			Cass	18,227	X
			Marion	7,008	
			Harrison	24,082	
			Upshur	15,618	X
			Rains	3,618	
			Total	127,270	
	XVI	5	Henderson	16,407	
			Freestone	9,309	
			Leon	7,880	
			Houston	14,994	
			Cherokee	21,672	
			San Augustine	6,327	
			Sabine	6,142	
			Newton	9,903	X
			Polk	10,911	
			San Jacinto	7,172	
			Trinity	7,181	
			Walker	10,343	
			Burleson	9,466	X
			Total	137,707	
		Grand Total		264,977	

Table 27.—Jasper County, South Carolina, Enumeration Districts, 1970 Housing Units, and Sample Segments

				Sample Segments				
E.D.*	H.U.	C.H.U.	C (.10)	V	W	X	Y	Z
1	442	442	44	04	30	21	15	27
2	246	688	69	41	67	58	52	64
3	367	1,055	106	78	104	95	89	101
4	393	1,448	145	115	141	132	126	138
5	168	1,616	162	152				
6	328	1,944	194	189	178	169	163	175
7	194	2,138	214			206	200	212
8	352	2,490	249	226	215	243	237	249
9	126	2,616	262		252			
10	288	2,904	290	263	289	280	274	286
11	416	3,320	332	300	326	317	311	323
12	243	3,563	356	337		354	348	
13	105	3,668	367		363			360

*E.D. "2" is incorporated place of Hardeeville
E.D. "8" is incorporated place of Ridgeland

Table 28.—S-44 Regional Rural Sociology Project Sample Allocation for 2-Stage Stratified Design

(1) State	(2) Stratum	(3) Primary Unit Selected	(4) $8(\text{Pop/ODU})_i$	(5) Y_i	(6) $Y_i/8(\text{Pop/ODU})_i$	(7) n_{ij}[1]
Alabama (4.165)	I	Monroe	33.320	236338	7093.0	13
		Tallapoosa	33.320	236338	7093.0	13
	II	Montgomery	33.320	350030	10505.1	19
		Clarke	33.320	350030	10505.1	19
Kentucky (4.058)	III	Whitley	32.464	293723	9047.6	16
		Harlan	32.464	293723	9047.6	16
	IV	Perry	32.464	233829	7202.7	13
		Wolfe	32.464	233829	7202.7	13
Louisiana (3.995)	V	Livingston	31.960	63293	1980.4	4
		E. Feliciana	31.960	3293	1980.4	4
	VI	Franklin	31.960	205489	6429.6	12
		Natchitoches	31.960	205489	6429.6	12
	VII	Union	31.960	90285	2824.9	5
		Union	31.960	90285	2824.9	5
N. Carolina (3.69)	VIII	Ashe	29.520	140096	4745.8	9
		Ashe	29.520	140096	4745.8	9
	IX	Anson	29.520	357992	12127.1	22
		Robeson	29.520	357992	12127.1	22
Tennessee (4.033)	X	Union	32.264	172545	5328.6	10
		Hancock	32.264	172545	5348.6	10
	XI	Houston	32.264	167408	5188.7	9
		Humphreys	32.264	167408	5188.7	9
Texas (3.661)	XII	Cass	29.288	127270	4345.4	8
		Upshur	29.288	127270	4345.4	8
	XIII	Newton	29.288	137707	4701.8	8
		Burleson	29.288	137707	4701.8	8
Mississippi (3.688)	XIV	Clay	29.504	261751	8871.7	16
		Holmes	29.504	261751	8871.7	16
	XV	Neshoba	29.504	261560	8865.3	16
		Lawrence	29.504	261560	8865.3	16
	XVI	Tunica	29.504	140340	4756.6	9
		Coahoma	29.504	140340	4756.6	9
					208068.6	378[2]

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[1] $= \frac{\text{Col. (6)}}{\text{Sum of Col. (6)}} \quad 375$

[2] This figure exceeds the prescribed overall sample size of 375 area segments because the N_{ij}'s have been rounded off.

Table 29.—Summary of Selected Sample by State and County

State	County	Number Segments	Expected N	Obtained N	Percent of Expected Obtained
Alabama	Monroe	13	104	58	55.7
	Tallapoosa	13	104	70	67.3
	Montgomery	19	152	108	71.0
	Clark	19	152	100	65.8
	Total	64	512	336	65.6
Kentucky	Whitley	16	128	78	60.9
	Harlan	16	128	61	47.6
	Perry	13	104	60	57.6
	Wolfe	13	104	67	64.4
	Total	58	464	266	57.3
Louisiana	Livingston	4	32	15	46.9
	E. Feliciana	4	32	5	15.6
	Franklin	12	96	36	37.5
	Natchitoches	12	96	37	38.5
	Union	10	80	39	48.8
	Total	42	336	132	39.3
Mississippi	Clay	16	128	81	63.2
	Holmes	16	128	111	86.7
	Neshoba	16	128	78	60.9
	Lawrence	16	128	79	61.7
	Tunica	9	72	30	41.6
	Coahoma	9	72	32	44.4
	Total	82	656	411	62.6
North Carolina	Ashe	18	144	121	84.0
	Anson	22	176	100	56.8
	Robeson	22	176	117	66.4
	Total	62	496	338	68.2
Tennessee	Union	10	80	62	77.5
	Hancock	10	80	71	88.7
	Houston	9	72	76	105.5
	Humphreys	9	72	59	81.9
	Total	38	304	268	88.2
Texas	Cass	8	64	36	56.2
	Upshur	8	64	34	53.1
	Newton	8	64	69	107.8
	Burleson	8	64	47	73.4
	Total	32	256	186	72.7
	Grand Total	378	3024	1953	64.6

Table 30. — Summary of S-79 Sample by State and County

State	County	Obtained Open	Obtained Non-open
Alabama	Clarke	122	0
	Monroe	75	0
	Fayette	107	23
	Tallapoosa	80	13
	Total	384	36
Georgia	Greene	89	0
	Liberty	57	0
	Union	61	0
	Total	207	0
Kentucky	Harlan	94	61
	Perry	67	30
	Whitley	93	50
	Wolfe	63	6
	Total	317	147
Louisiana	E. Feliciana	21	18
	Franklin	92	48
	Livingston	31	14
	Nachitoches	78	83
	Union	74	36
	Total	296	199
Mississippi	Clay	55	0
	Coahoma	18	0
	Holmes	77	0
	Lawrence	56	0
	Neshoba	94	0
	Tunica	31	0
	Total	331	0
North Carolina	Anson	83	4
	Ashe	93	0
	Robeson	109	0
	Total	285	4
South Carolina	Georgetown	58	38
	Jasper	50	0
	McCormick	44	0
	Total	152	38
Tennessee	Hancock	57	0
	Houston	60	0
	Humphreys	59	1
	Union	54	0
	Total	230	1
	Grand Total	2202	425

Table 31. — Eligible Counties in Georgia and South Carolina

Georgia

Dawson
Fannin
Gilmer
Lumpkin
Rabun
Towns
X Union
White
Haralson
Heard
Paulding
Stephens
Fayette
Meriwether
X Greene
Hancock
Jasper
Putnam
Saliaferro
Warren
Wilkes
Burke
Dodge
Laurens
Screven
Telfair
Calhoun
Clay
Quitman
Randolf
Schley
Terrell
Webster
Appling
Atkinson
Brooks
Emanuel
Jeff Davis
Lanier
Montgomery
Thomas
Toombs
Brantley
Bryan
Camden
Charlton
Clinch
Echols
Glynn
X Liberty
Long
McIntosh
Pierce
Wayne
Glascock
Marion
Taylor
Twiggs
Washington
Wilkison
Baker
Early
Murray
Chatooga
Wilcox

South Carolina

Oconee
Lancaster
Fairfield
X McCormick
Williamsburg
Kershaw
Allendale
Bamberg
Barnwell
Clarendon
Hampton
Lee
Sumter
Beaufort
Berkeley
Colleton
Dorchester
X Georgetown
X Jasper

APPENDIX E

Guttman Scale Analysis for Four Communications Items

GUTTMAN SCALE MODEL

GUTTMAN SCALE ANALYSIS

	News		Tele		TV		Radio		Total
SCALE SCORE	0	1	0	1	0	1	0	1	
4	0*	8	0*	8	0*	8	0*	8	8
3	11	8*	7*	12	0*	19	1*	18	19
2	23	7*	19	11*	9*	21	9*	21	30
1	30	1*	28	3*	26	5*	9*	22	31
0	23	0*	23	0*	23	0*	23	0*	23
TOTAL	87	24	77	34	58	53	42	69	111
PERCENT	78	22	69	31	52	48	37	63	
ERRORS	0*	16*	7*	14*	9*	5*	19*	0*	70

* RESPONSES IN ERROR

GUTTMAN SCALE MODEL

COEFFICIENT OF REPRODUCIBILITY	0.8423
MINIMUM MARGINAL REPRODUCIBILITY	0.6554
PERCENT IMPROVEMENT	0.1869
COEFFICIENT OF SCALIBILITY	0.5425

GUTTMAN SCALE MODEL

NEWS	TELE	TV	RADIO	OBSERVED	PREDICTED	CHI-SQUARE	CLASS SCORE
0	0	0	0	23	20.01	0.447	T0
0	0	0	1	22	20.07	0.186	T1
0	0	1	0	5	6.01	0.168	T0
0	0	1	1	12	15.35	0.729	T2
0	1	0	0	3	4.14	0.312	T0
0	1	0	1	7	5.53	0.392	T1
0	1	1	0	4	2.85	0.464	T3
0	1	1	1	11	11.88	0.066	T3
1	0	0	0	1	3.85	2.107	T0
1	0	0	1	2	4.01	1.009	T1
1	0	1	0	5	1.33	10.082	T0
1	0	1	1	7	3.92	2.422	T2
1	1	0	0	0	0.98	0.977	T0
1	1	0	1	0	2.05	2.049	T4
1	1	1	0	1	1.54	0.189	T4
1	1	1	1	8	7.50	0.034	T4

CHI-SQUARE	21.633
DEGREES OF FREEDOM	10
NUMBER OF CASES	111
REQUIRED PROBABILITY OF MISCLASSIFICATION	0.1600
STANDARD ERROR	0.0254
SCALE RELIABILITY	0.5945
FLAT RELIABILITY	0.6324
STANDARD ERROR	0.0646
AVERAGE SCORE	1.4742
STANDARD ERROR	0.1916

CORRELATION COEFFICIENTS

	NEWS	TELE	TV	RADIO
NEWS	1.0000	0.0783	0.4180	0.0939
TELE	0.0783	1.0000	0.3039	0.1960
TV	0.4180	0.3039	1.0000	0.1880
RADIO	0.0939	0.1960	0.1880	1.0000
SCALE-ITEM	0.2881	0.2856	0.4590	0.2260

		RADIO	TV	TELE	NEWS	
MARGINAL FREQUENCIES		69	53	34	24	
TRUE TYPES	T0	T1	T2	T3	T4	BETA
STARTING PARAMETERS	0.30263	0.28947	0.15789	0.14474		6.00000
PARAMETER ESTIMATES	0.30391	0.26400	0.18431	0.14955	0.09823	6.25088
STANDARD ERRORS	0.06282	0.07319	0.06761	0.06006	0.04435	0.99266

INFORMATION (SINGLE OBSERVATION) MATRIX

	T0	T1	T2	T3	BETA
T0	0.4380	-0.2752	-0.0806	-0.0513	0.1720
T1	-0.2252	0.5946	-0.2253	-0.0589	-0.7065
T2	-0.0806	-0.2253	0.5074	-0.1697	-0.0418
T3	-0.0513	-0.0589	-0.1697	0.4004	-0.1212
BETA	0.1720	-0.7065	-0.0418	-0.1212	109.3763

S-79 TECHNICAL COMMITTEE MEMBERS

Alabama	Calvin L. Vanlandingham
Georgia	H. Max Miller
Kentucky	A. Lee Coleman C. Milton Coughenour
Louisiana	Virginia P. Steelman
Mississippi	Wolfgang Frese
North Carolina	Glenn C. McCann
Puerto Rico	Reinaldo Calero
South Carolina	Edward L. McLean
Tennessee	Charles L. Cleland

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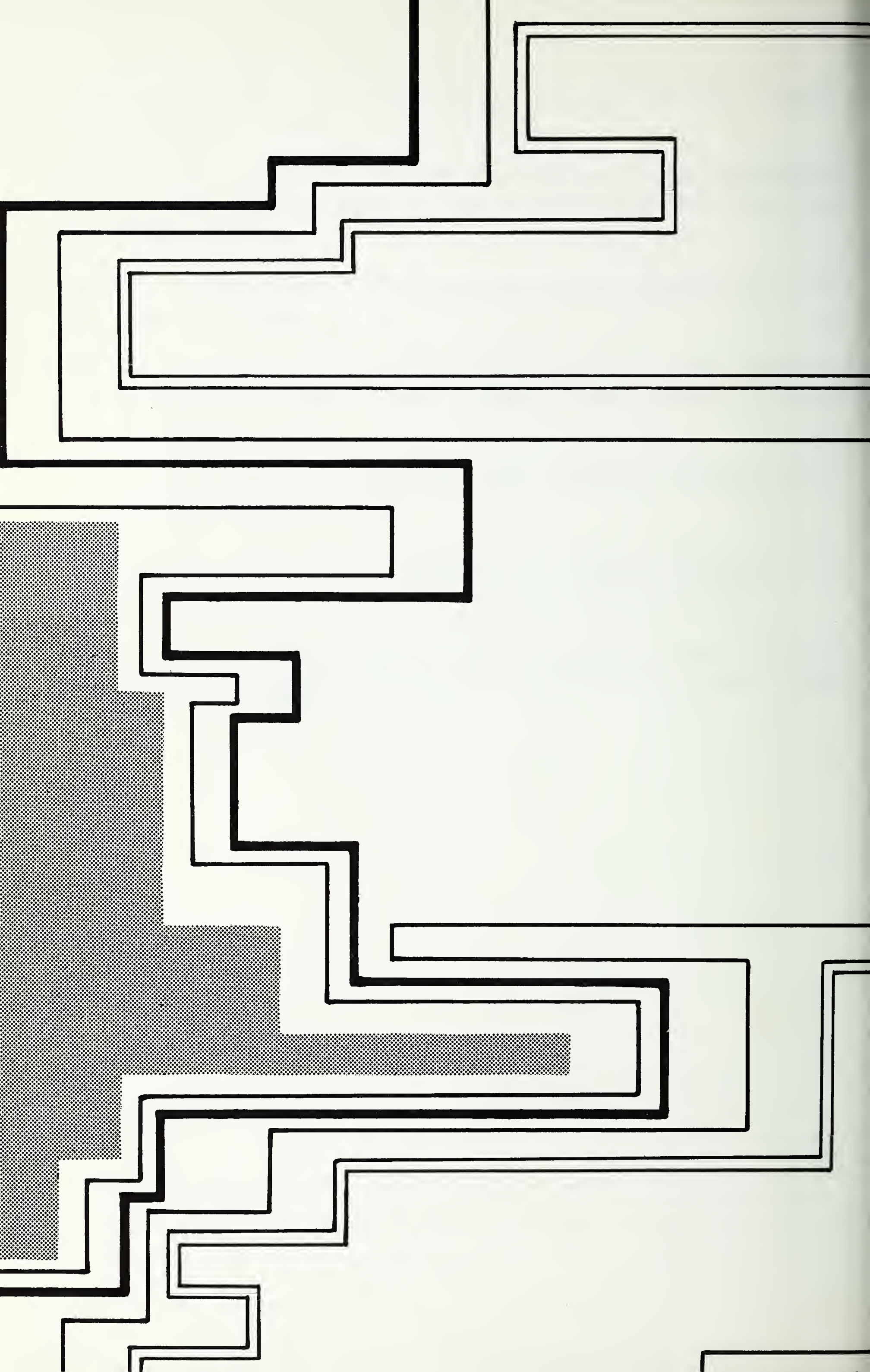

LOUISIANA AGRICULTURE

Economic Trends And Current Status

1940-1977

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Bulletin No. 718 June 1979

LOUISIANA STATE UNIVERSITY
AND AGRICULTURAL AND MECHANICAL COLLEGE
Center for Agricultural Sciences
And Rural Development

AGRICULTURAL EXPERIMENT STATION
DOYLE CHAMBERS, DIRECTOR

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PREFACE

In 1962, the Louisiana Agricultural Experiment Station published Bulletin 550 describing Louisiana Agriculture and changes that had occurred between 1930 and 1960. Because of a continual demand for general information on Louisiana agriculture, this bulletin updates the earlier version for the period 1940 to 1977 — highlighting changes since 1940 and the current status of the agricultural sector in the state. The writing is nontechnical and provides general information without attempting to explain in detail the many and complex factors that have caused the changes.

One objective of the bulletin is to correct some general misconceptions about agriculture. People note a decrease in farm numbers and some conclude that agriculture is a declining industry. *That is not correct. Agriculture is an important and, by many measures, a growing industry in Louisiana.* Value of output is increasing, farms are becoming more efficient, the average size of farms is increasing and cropland acreage has increased. Investment in machinery and equipment has increased tremendously as they have become increasingly sophisticated and costly. Farmers are better educated and have become better managers, more versatile in their production and marketing decisions. For example, they increased soybean acreage from around 200,000 acres in 1960 to over 2,900,000 acres in 1978, one of the most sudden and profitable revolutions in Louisiana agricultural history.

Costs of production have increased greatly over the years. Farmers' purchases of inputs, as well as marketing of farm products, has created a large and complex supply-marketing ''agribusiness'' sector which contributes heavily to off-farm but agriculturally oriented employment and income in Louisiana.

Agriculture is an industry based on renewable resources. With proper management, resources required for agriculture will be conserved for future production, and the agricultural sector of the economy will continue to grow. Though major changes have occurred in Louisiana agriculture in recent years, most of the changes have increased the industry's economic viability and provide a solid foundation for a continuing contribution to the state's economy.

Louisiana Agriculture
1940-1977
Economic Trends and Current Status

STEPHEN D. REILING AND FRED H. WIEGMANN*

I. INTRODUCTION

Agriculture has made an important contribution to Louisiana's economic growth and history. Though the state's economy has become more diversified in recent years, many measures show that agriculture ranks as one of the state's most important economic activities. Annual cash farm income in Louisiana averaged more than one billion dollars from 1972 to 1977. Agriculture is the base for a very large and complex supply-marketing "agribusiness" sector involved in advertising, insuring, processing, storing, transporting, and selling farm supplies and farm products. Like farming, the agribusiness sector is growing and becoming increasingly sophisticated as it provides necessary support for the farm sector of the state's economy. *Renewable* agricultural resources serve as a basis for future production and enhance the continuing importance of agriculture to Louisiana's economic future. Agriculture's contribution to the state's economy may become even more important as the ratio of tillable land to population decreases and world requirements for food and fiber continue to increase.

Purpose of the Study

Agriculture is a dynamic industry. Significant changes have occurred in agriculture over the years. Total land in farms has remained relatively constant, and cropland has increased. There has been a major decrease in the number of farms but the remaining farms have increased in size over time. Agricultural production has become more mechanized, more capital intensive, more sophisticated, and much more complex. These changes have resulted in a larger dollar volume of output and a more efficient commercial agriculture in Louisiana.

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Other adjustments have also occurred. Some crop and livestock enterprises have increased in importance while others have declined. Increased specialization and technological advances, within the agricultural production sector, have led to the development of a large agribusiness sector to service the needs of commercial farms in Louisiana.

While the examples cited do not exhaust the type of changes that have occurred, they illustrate the dynamic nature of Louisiana agriculture. The purpose of this study is to describe some of the significant changes that have taken place in recent years and the current status of agriculture in Louisiana. Data compiled from several sources illustrate the adjustments that have occurred over time. The time period considered in this study is 1940 through 1977, with emphasis on the period 1960-1976. (There may be occasional reference to 1978, for which data is yet incomplete.) An attempt has been made to identify the various sources of data used in the study.

This study does not provide a detailed explanation of the reasons for adjustments that have taken place since 1940. A detailed analysis of the complex economic, physical, and institutional factors underlying the changes would require a much lengthier and more technical approach. Instead, this report simply reviews statistical ‘‘highlights’’ and provides a general overview of the agricultural-agribusiness sector in Louisiana.

Organization and Scope of the Bulletin

Agricultural production in Louisiana is influenced by both natural and economic factors. These factors are discussed separately in Section II as they largely determine the character of the major farming areas in the state.

General data relating to Louisiana agriculture are presented in Section III. Farming areas, trends in farm numbers, and size and tenure patterns are discussed, as well as economic data pertaining to farm income and production costs.

The discussion in Sections IV and V focuses on trends in crop and livestock production in Louisiana. Data on acreage, yield, production, and location of production are presented for each of Louisiana's major crops. Similarly, livestock numbers, production, and location of production are also discussed.

Forestry, an important sector of agriculture, is discussed in Section VI. Section VII consists of a discussion of aquaculture, and Section VIII covers the ‘‘agribusiness’’ sector, which is growing rapidly in size and importance. The discussion focuses on the breadth of the agribusiness sector and its relationship to the total agricultural industry in Louisiana. The impact of technological and social change on rural areas is explored in Section IX. A summary and conclusions are presented in Section X.

II. FACTORS INFLUENCING LOUISIANA AGRICULTURE

Natural Factors

Climate

The geographic location of Louisiana in subtropical latitudes and its proximity to the warm waters of the Gulf of Mexico have a major influence on the climate of the state. Various surface features, such as lakes, streams, marshes, and elevation also influence local weather patterns. Summer weather in Louisiana is dominated by moist maritime tropical air carried over the state by prevailing southerly winds. The warm moist air creates conditions favorable for afternoon and evening thundershowers. Occasionally, westerly winds carry hotter and drier air into the state.

During the cooler seasons of the year weather conditions are more variable as the state is subjected alternately to warm tropical maritime air and cold polar continental air. Although warmed considerably by its southern movement, cold air sometimes causes large and sudden decreases in temperature. Louisiana is south of the regular track of large moisture-bearing storm centers. However, they occasionally influence the weather and usually result in extended periods of overcast skies and steady rain.

Temperature

Summer temperatures in Louisiana normally range from 85° to 95° F. during the afternoons and from 65° to 75° F. during the early morning hours. Winter temperatures usually vary from 55° to 65°F. during the afternoons and from 40° to 50° F. in the early morning hours. Extreme variations in temperature are not common in Louisiana. The highest temperature recorded in the state was 114° F. on August 10, 1936, at Plain Dealing in Bossier Parish. The lowest temperature recorded was –16°F. on February 13, 1899, at Minden, in Webster Parish. The southern part of the state is usually cooler during the summer and warmer during the winter than the northern part because of the stronger influence of the Gulf of Mexico.

Mild temperatures are important to Louisiana agriculture since they result in a relatively long growing season (see Figure 1). The growing season, or the number of days between the last freeze in the spring and the first freeze in the fall, varies from about 220 days in the northern part of the state to 350 days in the extreme south. Semi-tropical crops such as citrus fruits and sugarcane are grown primarily in the southeastern and south-central part of the state because of the relatively long growing season. In contrast, crops grown in the northern part of the state generally do not require as long a growing season.

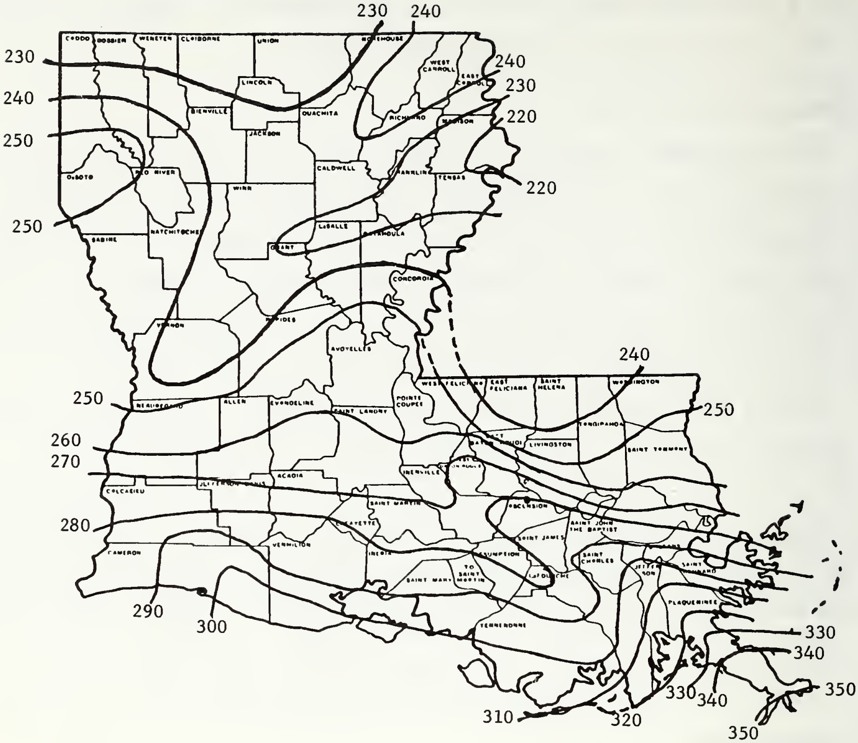


Figure 1.—The average length of the growing season in Louisiana (days).

Precipitation

Louisiana has one of the highest annual rates of rainfall of all states (see Figure 2). Annual rainfall varies from 48 inches in the northwest to 64 inches in the southeast. In general, precipitation increases as one moves from north to south and from west to east because of the influence of the warm moist air from the Gulf of Mexico. Precipitation occurs throughout the year; however, the summers are usually wetter and thundershowers occur frequently in the southern area. Periodic droughts occur occasionally throughout the state, however. Autumn is generally somewhat drier than the other seasons of the year.

Although adequate rainfall is essential, too much precipitation can hamper agricultural production. Extended periods of rain at planting time can force farmers to alter cultivation plans and crop selection, and excessive rain in the fall can interfere with harvesting. Occasional hurricanes, periods of very heavy precipitation, and infrequent freezes may also cause severe crop damage.

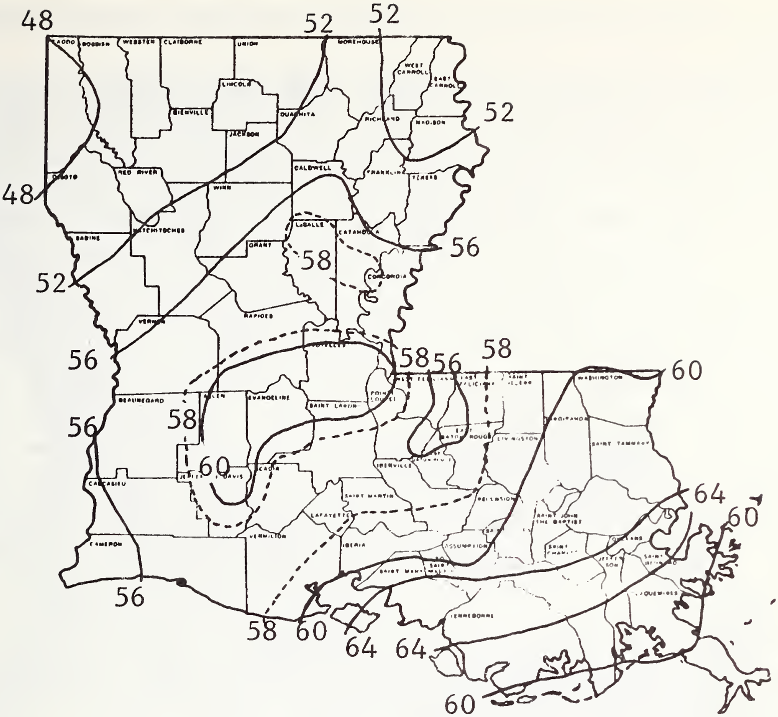


Figure 2.—Normal annual precipitation in Louisiana (inches).

Geography

There are approximately 31 million acres of total area in Louisiana. The lakes, streams, and other water bodies account for about 2.7 million acres or about 9 percent of the total area. Salt water and fresh water marshlands in the extreme southern part of the state cover about 3.7 million acres; thus, water covers about 20 percent of the total area of Louisiana.

Geologically, Louisiana is a newly formed area, and its soils were formed as submarine deposits. Five physiographic classifications exist in the state: uplands, bluffs, alluvial plains, prairies, and marshes, each formed in successive stages in the geological process.

The uplands consist of low, rolling, pine-covered hills and are designated "uplands" only in contrast to the low-lying land in the rest of the state. The highest elevation in Louisiana is 535 feet at Driskill Mountain in Bienville Parish. The uplands are located in three areas: north of Lake Pontchartrain and east of the Mississippi River, west of the Red River, and in the northcentral part of the state, between the Red and the Ouachita rivers. Livestock and forestry are the primary agricultural enterprises in the uplands.

The bluffs are on the southern fringe of the uplands, while the alluvial plains are in the flood plains of rivers, particularly the Mississippi, the Ouachita, and the Red River. A major part of crop production in Louisiana takes place in the alluvial plains. Prairies are most common in the southern part of the state, especially the southwest. The prairies also are important areas for agricultural production, especially rice, soybeans, and cattle. There is some agricultural production on land bordering the Gulf of Mexico and classified as "coastal marshland" soils (Figure 3). Rice is grown within a few miles of the Gulf and native cattle graze the marshlands in southwest Louisiana. Sugarcane is grown within sight of the Gulf in the southcentral area. Citrus fruit is grown along the Mississippi, which flows through the marshlands that extend more than 100 miles below New Orleans. The marshes of south Louisiana also provide habitat for fish, shrimp, crabs, and other seafood, as well as alligators, fur-bearing animals, and ducks and geese. There are several wildlife refuges in the marsh areas.

Soil Types

The general soil areas in Louisiana are shown in Figure 3. Soil fertility varies throughout the state. Some of it is low in natural fertility, especially the soils of the upland regions. On the other hand, the soils in the deltas of the Mississippi, Red, and Ouachita Rivers have a high plant nutrient level. The soils of the prairie area in southwest Louisiana are clay and clay loam. They also have an impervious base which, combined with an adequate water supply, is ideal for rice production. Peat-like soils exist in the coastal marshes.

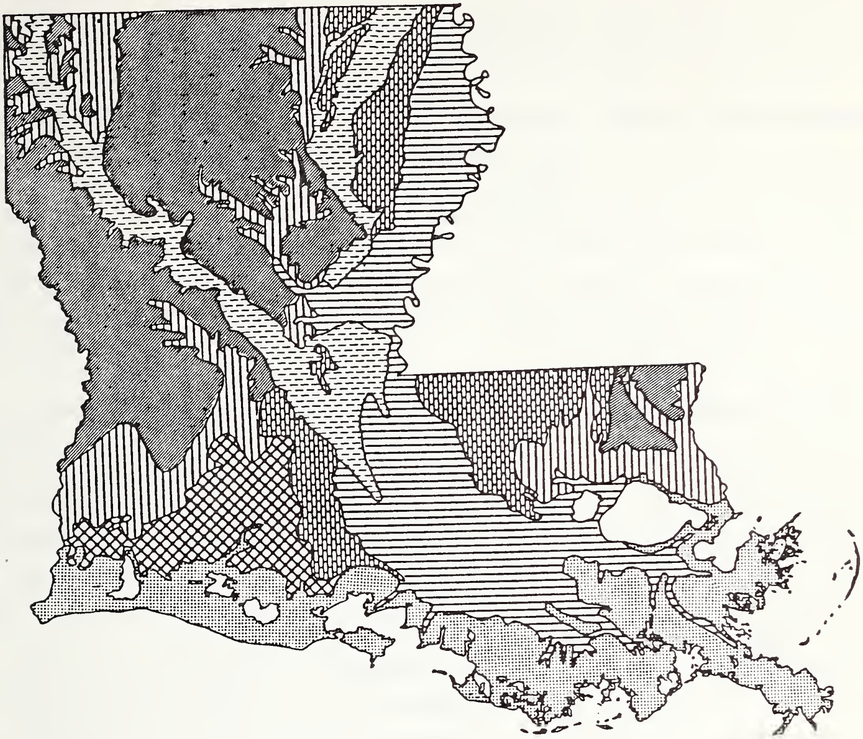
Economic Factors

Economic factors also influence agricultural production in Louisiana. The availability of required resources and principles of economies of size and comparative advantage are especially important. Resources, or factors of production, are usually classified in four categories: land, labor, capital, and management. Each category is discussed below.

Land

As noted earlier, water bodies and marshlands account for about 20 percent of Louisiana's 31 million acres of surface area. Urban and built-up areas occupy about a million acres, and 15 million acres are forested. Forest lands account for more than 50 percent of the total land area in

Figure 3.—General soil areas in Louisiana.



▨ GENTLY SLOPING TO HILLY COASTAL PLAIN - Shubuta, Ruston, Bowie, Lucy, Troup, Kirvin, Nacogdoches, Susquehanna, Ora, Sawyer, Boswell

▦ LOESSIAL HILLS AND MISSISSIPPI TERRACES - Olivier, Loring, Memphis, Providence, Lexington, Calhoun, Jeanerette

▥ FLATWOODS AREAS - Caddo, Beauregard, Acadia, Frost, Calhoun, Zachary, Wrightsville

▩ COASTAL PRIARIES - Crowley, Midland, with Beaumont, Bernard, Acadia

▤ RECENT ALLUVIUM (MISSISSIPPI RIVER ALLUVIAL SOILS) - Sharkey, Mhoon, Commerce, Tunica

▭ RECENT ALLUVIUM (ALLUVIAL SOILS OF THE RED AND OUACHITA RIVERS) - Moreland, Norwood, Yahola, Perry, Portland

░ COASTAL MARSHLANDS - Marsh Peats, Mucks, Clays, and Harris, with Swamp Peats, Mucks, and Clays

Source: Lytle, S. A., Morphological Characteristics and Relief--Soils in Louisiana, Bulletin No. 631, Louisiana Agricultural Experiment Station, November, 1968.

Louisiana. Farm lands account for 9.1 million acres, or about 31.7 percent of the total land area.

Data in Table 1 show that there was a decrease in total land in farms during the period 1964-1974. Farmland acreage in 1974 was about 1.3 million acres less than in 1964. However, there was an *increase* in total cropland and harvested cropland during the decade. Harvested cropland in Louisiana increased 36 percent during the period. While harvested cropland accounted for only 25.7 percent of the total land in farms in 1964, it comprised 39.7 percent of total farmland in 1974. In comparison, there was a large decrease (48 percent) in the number of acres of woodland and woodland pasture between 1964 and 1974. The increase in cropland indicates that Louisiana farmland is being used more intensively now than it was in 1964, partly because woodland and woodland pasture has been converted to soybean production.

Land is a fixed resource. Continued population and industrial growth in Louisiana will increase competition for land in the future. This may affect agriculture in some areas of the state. For example, agriculture may be crowded out of fringe areas around major population centers. Industrial development on both banks of the Mississippi River, between Baton Rouge and New Orleans, will continue to displace some agricultural production. Development on the west side of the Atchafalaya Basin, between Lafayette and Morgan City, may also gradually displace agriculture.

While urban and industrial growth will influence agricultural production in local areas, these factors should not cause major problems for Louisiana agriculture in general. Most of Louisiana's farmland is located in predominantly rural areas, and the long range outlook for converting new land to agricultural production is good.

Labor

Historically, Louisiana agriculture was labor intensive. Large amounts of labor were required for the production of sugarcane and cotton, particu-

Table 1.—Farm land use in Louisiana for selected years

Category	1964	1969	1974
	Acres		
Total Land in Farms	10,411,500	9,788,662	9,133,275
Total Cropland	4,864,405	5,842,350	5,590,448
Cropland Harvested	2,672,650	3,443,108	3,628,199
Cropland Used Only for Pasture	1,739,150	1,647,747	1,426,704
Other Cropland	452,605	751,495	535,585
Woodland Including Woodland Pasture	2,966,200	1,916,311	1,531,661
All Other Land	2,580,145	2,030,001	2,011,126

Source: Compiled from *Census of Agriculture* for the designated years. (Acreage for "Land in Farms" reported by the Crop and Livestock Reporting Service, USDA, is greater than census figures.)

larly during planting and harvesting. However, increased mechanization has significantly reduced labor requirements for these crops, although others still require large amounts of labor. For example, production and harvesting commercial vegetables, sweet potatoes, and strawberries is still largely labor intensive in Louisiana.

It is difficult to estimate the size of the farm labor force in Louisiana because it varies throughout the year in relation to the peak and off-peak labor demand periods on farms. Data in Table 2 indicate the number of workers on farms for selected months in 1975. The total farm labor force ranged from 54,000 in January to 76,000 in July. The number of family workers was highest in July, during school vacation. The number of hired farm workers was highest in October, the peak of the harvest period for many of Louisiana's crops.

According to the Louisiana Department of Employment Security, the use of seasonal or part-time agricultural labor has declined in recent years. Seasonal employment averaged about 6,340 workers per month in 1971 compared to only 3,625 workers in 1975. October and November traditionally have been the peak months for seasonal labor. The trend toward larger, more mechanized farms has contributed to the decline in total seasonal employment.

In the past, interstate migratory labor made up a large part of the seasonal work force in Louisiana. Since 1975, however, very few migratory workers have been employed in the state; however, some migratory labor was employed during the strawberry harvest in 1975.

Modern farming practices require the use of increasingly complex equipment, which in turn increases the need for more highly skilled farm labor. Workers with the necessary skills are difficult to find at the prevailing wage rate. Therefore, farmers tend to recruit semi-skilled or unskilled workers with ability to learn the required skills. However, upon becoming skilled, many of the workers leave agricultural employment for higher paying jobs in other industries. This has resulted in an uncertain labor supply for farmers and has added emphasis to the trend toward increased mechanization.

Table 2.—Number of workers on Louisiana farms during selected months in 1975

Type of Labor	Month			
	January	April	July	October
Hired	17,000	20,000	22,000	27,000
Family	37,000	50,000	54,000	41,000
TOTAL	54,000	70,000	76,000	68,000

Source: Compiled from various issues of *Farm Labor*, Statistical Reporting Service, Crop Reporting Board, U.S. Department of Agriculture.

Farm wage rates in Louisiana have increased significantly since 1960. In July, 1960, the average hourly wage rate was 62 cents, compared with an average $1.02 per hour for the United States. Farm wages in Louisiana were among the lowest in the nation in 1960. However, in July 1976, the average hourly wage rate in Louisiana was $2.11, compared with a national average of $2.29. At least 20 other states had a lower average farm wage rate than Louisiana in 1975. Of the 13 states in the southeast and south-central parts of the United States, only Florida and Oklahoma had an average wage rate that was higher than that reported for Louisiana. In 1975, hired agricultural workers in Louisiana received $64.9 million in wages. This does not include wages paid to farm operators or their families.

Capital

The trend toward larger farms and the adoption of improved technology have increased the importance of capital as a resource in commercial agriculture. The most important source of capital for farm mortgage or real estate loans in 1976 was the Federal Land Bank System, as shown in Table 3. Life insurance companies ranked second in importance, followed by individuals and commercial banks.

The growth in farm real estate debt in Louisiana since 1960 has been dramatic. The 1975 farm real estate debt was more than five times larger than in 1960. This does not, however, mean that Louisiana farmers have an excessive debt burden. It has been estimated that the value of real estate debt in the U.S. and in Louisiana was about 15 percent of the value of land, buildings, machinery, and equipment on farms in 1977. In other words, farm proprietors' equity was about 85 percent of the value of farm holdings. The average value of assets on Louisiana farms in 1977 was $206,977. Debt amounted to $31,432. Farm equity was $175,545 for a debt-asset ratio of 15.2. For comparison, average assets per farm for the

Table 3.—Louisiana farm real estate debt, by lender group, for selected years

Lender Group	Year				
	1960	1965	1970	1975	1976
	1,000,000 dollars				
Federal Land Banks	33.1	58.2	138.4	273.2	291.2
Life Insurance Companies	24.1	55.6	139.1	155.9	167.1
All Banks	30.0	47.7	70.1	120.5	123.3
Farmers Home Admin.	9.3	17.6	31.3	43.3	47.3
Individuals & Others	38.3	53.5	73.5	121.3	145.8
TOTAL	134.8	232.6	452.4	714.2	774.7

Source: *Agricultural Finance Statistics*, Economic Research Service, U.S. Department of Agriculture, Washington, D.C., July 1976 and for 1976 *Farm Real Estate Debt*, Statistical Bul. #16, Economic Analysis Division, Farm Credit Administration, January, 1977.

U.S. were $241,461, debts were $37,935, and equity was $203,526, for a debt-asset ratio of 15.7 in 1977.[1] In general, farmers own a larger portion of total capital assets than most non-farm business operators.

The average interest rate on farm real estate loans outstanding in the Delta States (Arkansas, Mississippi, and Louisiana) was 7.1 percent in 1975, compared to a national average rate of 6.7 percent. Only the Southeast Region had a higher average interest rate (7.2 percent) than the Delta States. The average interest rate in the Delta States has increased steadily from 5.2 percent in 1959.

Non-real estate loans to Louisiana farms in 1975 totaled about $337.7 million. These loans were for operating capital and other short-term uses. Commercial banks and production credit associations were the leading lending institutions for non-real estate loans. They provided $155.9 million and $149.3 million, respectively, to Louisiana farmers.

Management

Management, like land, labor, and capital, is a resource. The owner-operator of a family farm is a decision-maker or manager as well as a laborer. While labor input can be measured fairly accurately, the management function cannot be measured precisely. Managerial ability varies among individuals, and it is difficult to make general statements or quantitative assessments of farm management input. For example, a farmer driving his tractor while plowing may also be making mental plans for another farm operation the next day or a month later, or he may be deciding to plow deeper or shallower or wider. That is management. It is difficult, in this example, to separate management from labor and attach a value to management. However, improved education and training of farmers in recent years has increased the number of good managers. Many young farmers have acquired a college education to help prepare them to manage and operate their farms effectively.

The management function is very important in agriculture. Basically, the owner-operator of a family farm performs three managerial functions: supervision, coordination, and entrepreneurship. Supervision consists of overseeing the day-to-day operations of the firm and insuring that each task is performed correctly. Coordination is broader in scope; it involves planning and integrating tasks to insure that the necessary resources required to accomplish them are available in sufficient quantity and at the proper time. The essential feature of coordination is that every decision must be made in relation to all other decisions already made or likely to be made.

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[1] *Balance Sheet of the Farming Sector,* Supplement #1, Agriculture Information Bulletin No. 416, ESCS, USDA, October, 1978.

Entrepreneurship involves making major decisions and broad adjustments regarding total resources use on farms, such as the choice of enterprises, when and how to sell the output, and the level of technology to be used. Furthermore, it involves bearing the risk and uncertainty of the outcome associated with those decisions that influence financial success or failure of the firm. The owner-operator of the family farm must bear these risks, in addition to performing the functions of laborer, supervisor, and coordinator.

Other Economic Factors

Availability of resources is not the only economic factor that influences agricultural production. The concepts of ''comparative advantage'' and ''economies of size'' are especially useful for understanding some of the conditions and trends in agriculture.

Significant differences in climate, soil types, and topography result in specialization in agricultural production. That is, production of a particular crop or livestock product is often concentrated in a certain area of the state. The principle of comparative advantage helps to explain why this specialization occurs as well as which crop or livestock product should be produced in a given region. According to this principle, a region should specialize in the production of that product for which it has the greatest absolute advantage or the least comparative disadvantage. For example, suppose one region cannot achieve yields as high as other regions. This disadvantaged region should specialize in the production of the product in which it comes closest to achieving the yields in other areas. Similarly, a region that can produce higher yields for all crops should specialize in the one in which its yield advantage is greatest. Organizing production in this manner results in a net increase in the aggregate output of agricultural production in the state and enhances Louisiana's terms of trade with other areas.

Economies of size is an economic concept that refers to the reduction in cost per unit of output often resulting from increases in the quantity of resources employed to produce the product. That is, the average total cost of producing a unit of output declines as a farm increases in size, at least up to a certain size producing unit. This is due to the increased feasibility of introducing more efficient production methods and increased specialization of the labor tasks. Increasing the size of a farm allows the farmer to spread his fixed or overhead costs over more units of output, thus decreasing the cost per unit. This is important because fixed costs account for a large part of the total cost of producing agricultural products. Economies of size has been a major factor behind the trend toward larger farms in recent years.

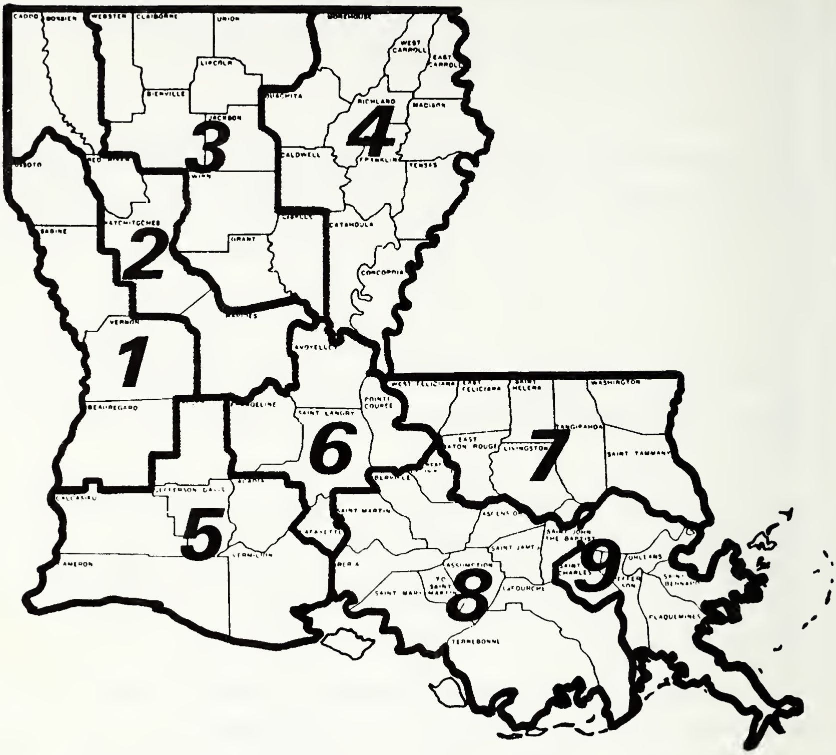
III. GENERAL DATA ON LOUISIANA AGRICULTURE

Farming Areas in Louisiana

The physical and economic characteristics described above influence the organization and location of Louisiana agriculture. Nine different ''type-of-farming'' areas in the state have been defined. A farming area is defined as an area consisting of a generally similar pattern of agriculture production. The area boundaries shown in Figure 4 do not precisely define farming areas in Louisiana because they use parish boundaries. Farming area boundaries usually exist where there is a distinct change in topography or soil type, which rarely occurs along parish boundaries. However, the map provides a generally useful indication of the location of farming areas within the state.

Each farming area is characterized by a different set of major agricultural enterprises. For example, sugarcane, rice, oranges, and strawberries are produced in separate and distinct areas. Other enterprises may traverse several areas that possess the physical characteristics required for production. Major enterprises typically found in the various farming areas are summarized below:

1. **Western Dairy, Poultry, Livestock, and Pine Area:** Timber, milk, broilers, sheep and lambs, cattle and calves.
2. **Red River Cotton, Cattle, and Soybean Area:** Cotton, soybeans, cattle and calves, corn, hogs and pigs, pecans, wheat, sorghum, hay, horses.
3. **North Central Dairy, Poultry, and Pine Area:** Timber, peaches, eggs, broilers, hogs and pigs, Irish potatoes, cattle and calves, horses.
4. **Mississippi Delta Cotton, Soybean, and Beef Area:** Cotton, soybeans, corn, hogs and pigs, wheat, sorghum, cattle and calves, Irish and sweet potatoes, pecans.
5. **Southwest Rice, Soybean, Beef, and Dairy Area:** Rice, soybeans, cattle and calves, milk, sheep and lambs, horses, corn.
6. **Central Mixed Farming Area:** Corn, soybeans, cotton, rice, sugarcane, sweet and Irish potatoes, cattle and calves, hogs and pigs, sheep and lambs, horses, sorghum.
7. **Southeast Dairy, Poultry, Truck, and Pine Area:** Milk, strawberries, cattle and calves, hogs and pigs, Irish potatoes, corn, nursery and greenhouse crops, broilers and eggs.
8. **Sugarcane Area:** Sugarcane, corn, soybeans, Irish potatoes, cattle and calves.
9. **Truck and Fruit Area:** Citrus, vegetables, nursery and greenhouse products.



Type of Farming Areas

1. Western Dairy, Poultry, Livestock, and Pine Area
2. Red River Cotton, Cattle, and Soybean Area
3. North Central Dairy, Poultry, and Pine Area
4. Mississippi Delta Cotton, Soybeans, and Beef Area
5. Southwest Rice, Soybean, Beef, and Dairy Area
6. Central Mixed Farming Area
7. Southeast Dairy, Poultry, Truck, and Pine Area
8. Sugar Cane Area
9. Truck and Fruit Area

(Revised 1974)

Figure 4.—Farming areas in Louisiana.

Each of the major crops and livestock enterprises is discussed later in the publication. Trends in acreage, yield, and total production since 1940 are presented to illustrate the changes that have occurred and the current relative importance of the various enterprises.

Table 4.—Number of farms and average size of farms in Louisiana for selected years

Year	Total Number of Farms*	Average Size of Farm
		(acres)
1940	150,007	66.6
1945	129,295	77.6
1950	124,181	90.2
1954	111,127	103.0
1959	74,438	139.0
1964	62,466	166.7
1969	42,269	231.5
1974	33,240	275.0

*Numbers are not completely comparable because of changes in the definition of a farm that occurred in 1959 and again in 1974. ("Number of Farms" reported by the Crop & Livestock Reporting Service, USDA, is greater than census figures).

Source: *Census of Agriculture* for the years designated.

Number and Size of Farms

There has been a continual and rapid decline in the number of farms in Louisiana since 1940 (Table 4). This trend is consistent with the general decrease in the number of farms throughout the United States. There were 150,000 farms in Louisiana in 1940, compared to about 33,000 in 1974.

It should be noted that the dramatic decline in farm numbers over time is *not* an indication that farming is a declining industry. In fact, part of the noted decline is more imaginary than real. Because of the way a farm is defined for census purposes, a plantation with 15 sharecroppers was counted as 15 separate ''farms'' in early censuses. As the number of sharecroppers declined there was a corresponding decrease in the number of ''farms'' even though the basic farm unit (the plantation) still existed. In other words, as the plantation passed from 15 sharecropping operations to a single operation utilizing hired labor, the number of farms decreased from 15 to one. Thus, part of the apparent decline in farm numbers in Louisiana has been caused by changes in institutional arrangements at the farm level.[2] Since the plantation owner made the major decisions for sharecroppers, the 15 ''farms'' of early censuses were ''paper'' farms; they did not actually exist as separate and independent units. The decline in this form of sharecropping accounts for much of the decline in farm numbers prior to 1959.

Furthermore, part of the decrease in farm numbers between 1940 and 1974 was caused by two changes in the definition of a farm. Prior to 1959, a farm was defined as a unit of 3 or more acres if the annual value of agricultural products, exclusive of home garden products, was $150 or more. A unit of less than 3 acres was also classified as a farm if the value of agricultural products sold was $150 or more.

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[2] See: Fred H. Wiegmann, ''Some Implications from the 1959 Census of Agriculture,'' *Louisiana Rural Economist,* May 1961, p. 4.

In the 1959, 1964, and 1969 census years, a farm was defined as a unit of 10 acres or more if the annual value of agricultural products was $50 or more. A unit of less than 10 acres that produced products valued at $250 or more was also classified as a farm. In 1974, the definition of a farm was again modified. Acccording to the new definition, a farm is any unit, regardless of size, that sells at least $1,000 of agricultural products annually.

Each change in the definition of a farm reduced the number of units that were classified as a farm, thus causing part of the decrease in the number of farms. Some of the units should probably never have been classified as farms in the first place. Their inclusion overstated a base for measurement which now leads to an overstatement of the extent of decline in farm numbers.

The trend toward fewer farms has been accompanied by a trend toward larger farms. In 1974, the average farm size in Louisiana was 275 acres, compared to only 67 acres in 1940. This trend has been caused by two major factors. First, the decline in sharecropping and the consolidation of land holdings by owners have had a positive effect on farm size. Second, smaller farms have been purchased and added to other farms to take advantage of economies of size. As small farms are combined to form larger units, more efficient production methods and equipment can be used, and costs per unit of output generally decline.

Data in Table 5 further illustrate the change in farm numbers and size in

Table 5.—Farm numbers by class, value of selected farm resources, and farm tenure for selected years, Louisiana

	Year			
	1959	1964	1969	1974
Farm sales less than $2,500	39,618	42,776	23,077	15,382
Farm sales more than $2,500	34,715	19,658	19,158	17,818
Number of farms with sales $2,500 to $19,999	—	14,416	12,691	8,892
Number of farms with sales $20,000 up	—	5,242	6,467	8,926
Value of land and buildings per farm	$23,719	$38,636	$74,414	$140,754
Value of machinery and equipment per farm	NA*	NA*	$10,164	$21,470
Farm tenure				
Full owner	44,264	37,439	24,586	20,128
Part owner	11,755	12,617	10,918	8,765
All tenants	17,950	12,151	6,765	4,347

*Data not available

Source: Compiled from the *Census of Agriculture* for the designated years.

Louisiana. The number of non-commercial farms, or farms with annual farm sales of less than $2,500, declined by 61 percent, while commercial farms declined 48.7 percent during the period 1959-1974. Similarly, farms with gross sales less than $20,000 declined by 38 percent from 1964 to 1974, while those with sales of $20,000 and over increased by 70 percent (Table 5). The 1974 census year was the first in which commercial farms outnumbered non-commercial farms in Louisiana.

The average value of land and buildings per farm increased more than 600 percent between 1959 and 1974, from nearly $24,000 per farm in 1959 to nearly $141,000 in 1974. Similarly, the value of machinery and equipment per farm doubled during the 5-year period 1969-1974. The reader should note that part of the increase in value has been caused by inflation.

Farm Tenure

Farm tenure data are also presented in Table 5. Tenure refers to the type of farm ownership — full owner, part owner, and tenant. The data indicate a substantial decline in the number of tenant-operated farms in Louisiana between 1959 and 1974. In 1959, 24 percent of the farms were operated by tenants. By 1974, only 13.1 percent were tenant-operated. However, renting land on a cash or share lease continues to be a popular alternative because it provides a way for farmers to expand their farming operations without incurring the high capital cost associated with purchasing land.

The percent of farms operated by full owners remained almost constant between 1959 and 1974 (59.5 percent versus 60.6 percent, respectively). During the same period, the percent of farms operated by part owners increased from 15.8 to 26.4 percent of the total number of farms.

Cash Receipts

Total cash farm receipts, which represent the gross income Louisiana farmers receive from the sale of crops, livestock and livestock products, and government programs, are shown in Table 6.

Cash receipts from crops increased from $68.8 million in 1940 to $851 million in 1977. Louisiana farmers received a record $961.5 million for the crops marketed in 1974. Receipts from crops doubled between 1971 and 1977.

Cash receipts from livestock marketings increased from $26.1 million in 1940 to $406.0 million in 1977. Livestock receipts reached a high of about $408 million in 1973. Receipts from livestock marketings generally accounted for 25 to 35 percent of total cash farm receipts in Louisiana during the period 1940-1977.

The level of government payments used to stabilize prices and incomes received by farmers was quite variable during the period. Payments were relatively higher from 1966 to 1973, varying from $43 million to $55

Table 6.—Cash farm receipts from crop and livestock marketings and government payments, Louisiana, 1940-1977

Year	Cash Farm Receipts From Crop Marketings	 Livestock Marketings	 Government Payments	Total Cash Farm Receipts
	----------------	$1,000,000	----------------	
1940	$ 68.8	$ 26.1	$21.1	$ 113.9
1941	84.5	33.3	15.9	133.6
1942	140.0	43.8	8.8	192.5
1943	186.3	57.6	16.6	260.5
1944	171.4	60.9	16.5	248.8
1945	186.5	72.5	12.4	271.4
1946	177.2	88.6	11.8	277.6
1947	230.7	112.9	9.1	352.6
1948	246.7	114.1	8.6	369.4
1949	240.4	104.0	9.1	353.5
1950	228.4	97.0	11.4	336.8
1951	262.9	121.1	11.6	395.5
1952	322.2	108.6	9.5	440.4
1953	292.3	108.7	6.7	407.7
1954	263.9	113.7	11.3	389.0
1955	258.2	114.7	10.3	383.2
1956	247.1	120.2	13.1	380.4
1957	201.8	140.1	21.6	363.4
1958	186.0	167.4	29.7	383.1
1959	234.2	147.8	13.7	395.7
1960	231.1	142.0	15.1	388.2
1961	258.1	154.0	16.5	428.6
1962	264.3	163.9	19.6	447.8
1963	337.7	158.4	16.8	512.9
1964	320.4	163.6	22.1	506.1
1965	295.7	189.4	22.1	507.3
1966	306.5	220.7	51.8	579.0
1967	369.7	215.9	55.5	641.0
1968	408.0	229.0	50.7	687.7
1969	355.4	254.0	52.3	661.7
1970	378.2	274.0	55.1	707.3
1971	429.1	265.8	50.0	744.7
1972	472.1	323.0	51.0	846.1
1973	723.3	407.7	43.3	1,174.3
1974	961.5	334.8	13.6	1,309.9
1975	794.6	315.0	18.7	1,128.3
1976	868.4	405.5	7.5	1,281.4
1977*	851.0	406.0	44.4	1,301.4

Source: Compiled from: L. L. Fielder, C. O. Parker, and J. B. Penn, *Agricultural Statistics for Louisiana, 1909-1968*, Department of Agricultural Economics and Agribusiness, Louisiana Agricultural Experiment Station, in cooperation with the Statistical Reporting Service, U.S. Department of Agriculture, D.A.E. Research Report No. 397, June 1969; L. L. Fielder and S. L. Guy, *Agricultural Statistics for Louisiana, 1964-1972*, D.A.E. Research Report No. 458, October, 1973; No. 496, November, 1975; and No. 523, August, 1977.

*Preliminary

million paid to Louisiana farmers. Payments decreased considerably after 1973, declining from $13.6 million in 1974 to $7.5 million in 1976. The lower payments reflect suspension of government programs designed to compensate farmers for decreasing production of certain commodities. These programs were practically eliminated in 1973 as farmers were encouraged to expand production to alleviate shortages of certain commodities to meet world food needs. Further changes in policy, production and markets resulted in payments estimated at $44.4 million in 1977, of which $30.9 million was for rice.

Cotton and sugarcane programs accounted for most of the government payments received by Louisiana farmers. For example, set aside and price support programs for cotton resulted in the payment of $31.2 million to Louisiana farmers in 1973. Payments to sugarcane farmers under the Sugar Act totaled $9.6 million the same year. Hence, cotton and sugarcane programs accounted for 94 percent of the $43.3 million in government payments received by Louisiana farmers in 1973, and wheat and feed grain programs accounted for most of the remaining government payments to farmers. In 1975, Sugar Act payments totaled $8.6 million (for the 1974 crop) and payments under the cotton program declined to $6.4 million. The Sugar Act expired December 31, 1974.

Total cash farm receipts increased dramatically between 1940 and 1977, reflecting increases in the value of livestock and crop marketings during the period. Total receipts averaged $190 million for the 5-year period 1940-1944 and increased to an average of over $1 billion per year for the period 1972-1977. Farmers received a record high of $1.3 billion for their products in 1977. Total cash farm receipts more than doubled between 1965 and 1977.

The increase in cash receipts during the period was not due entirely to expanded agricultural production in Louisiana. Since cash receipts are reported in dollar values, yearly price variations and inflationary trends during the period affect the level of cash receipts. Part of the increase in cash receipts reflects inflation as well as increases in agricultural production, particularly since 1972.

Data in Table 7 provide a detailed breakdown of cash receipts according to major commodities produced in the state. Commodities are also ranked according to their contribution to total receipts for selected years to illustrate changes that have occurred over time. For example, in 1960, cotton was the number one crop in Louisiana in terms of cash receipts. By 1977, however, soybeans had become the number one crop and cotton had slipped to third position. Receipts from cattle and calves ranked second in 1960 and 1977 relative to other commodities, while sugarcane changed from fifth in 1960 to sixth in 1977. Individually, fruits, nuts, and vegetables account for a relatively small part of total cash farm receipts. When

Table 7.—Ranking of major commodities, by cash farm receipts, Louisiana, selected years[1]

Commodity	Year 1960		1965		1970		1977*	
	Cash Receipts	Rank	Cash Receipts	Rank	Cash Receipts	Rank	Cash Receipts	Rank
	($1,000)		($1,000)		($1,000)		($1,000)	
Soybeans	8,968	9	31,929	6	96,255	3	319,047	1
Sugarcane	38,808	5	48,563	5	62,179	6	101,599	6
Rice	58,109	3	82,551	3	101,666	2	170,888	4
Cotton lint & seed	83,390	1	91,139	2	68,080	5	179,519	3
All fruits, nuts, & vegetables	14,637	7	12,255	9	16,495	9	32,974	9
Other crops[2]	27,226	—	29,299	—	27,546	—	46,997	—
TOTAL CROPS	231,138	—	295,736	—	372,221	—	851,024	—
Dairy products	39,362	4	52,976	4	73,475	4	114,527	5
Cattle & calves	67,384	2	91,581	1	145,451	1	185,787	2
All chickens	11,578	8	15,891	8	24,640	7	59,356	7
Eggs	15,407	6	21,768	7	23,234	8	31,274	8
Other livestock	8,242	—	7,278	—	10,348	—	15,050	—
TOTAL LIVESTOCK	141,973	—	189,494	—	278,148	—	405,994	—
TOTAL ALL COMMODITIES	373,111		485,230		650,469		1,257,018	

*Preliminary.

[1] Not including government payments.

[2] Includes income from nursery, greenhouse, and farm woodlots. Commercial forestry is discussed later in the bulletin.

Source: Compiled from various issues of *Louisiana Farm Income,* Louisiana Crop and Livestock Reporting Service, USDA, and Department of Agricultural Economics and Agribusiness, Louisiana State University

viewed collectively, however, they are among the nine most important enterprises in Louisiana. The data show that soybeans, cotton, sugarcane, rice, dairy products, cattle and calves, and poultry products are the major farm income-producing enterprises in the state, excluding income from commercial forestry production.[3]

Production Expenses

Farmers contribute to the growth of the economy through their purchases of goods and services needed for production. Their purchases create income and generate employment in the agribusiness and farm services sector — $993 million in 1977. Farm production expenses for the period 1949 to 1977 are shown in Table 8. Both operating and fixed expenses are reported. Operating expenses, which consist of the "variable" costs (seed, fertilizer, labor, pesticides) incurred for production for a given year, increased from about $146 million in 1949 to more than $666 million in

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[3] Income from forestry is discussed later in the bulletin. Income from crawfish and catfish farming is also not included in these data.

Table 8.—Farm production expenses for Louisiana, 1949-1977

Year	Operating Expenses[1]	Fixed Expenses[2]	Total Production Expenses[3]
	-----------$1,000,000-----------		
1949	146.4	44.1	190.5
1950	161.4	50.5	211.9
1951	179.2	57.0	236.2
1952	195.3	60.3	255.6
1953	188.7	61.5	250.2
1954	185.2	62.0	247.2
1955	186.9	64.2	251.1
1956	193.2	64.3	257.5
1957	191.3	66.8	258.1
1958	197.9	69.2	267.1
1959	209.6	74.4	284.0
1960	203.1	72.2	275.3
1961	209.2	73.7	282.9
1962	218.8	76.5	295.3
1963	240.3	88.2	328.5
1964	243.6	92.9	336.5
1965	253.9	100.4	354.3
1966	271.0	114.4	385.4
1967	292.0	129.0	421.0
1968	309.0	137.9	446.9
1969	312.1	142.4	454.5
1970	327.8	146.3	474.1
1971	399.9	141.2	541.1
1972	435.2	212.1	647.3
1973	508.4	250.6	759.0
1974	627.4	326.5	953.9
1975	618.8	290.3	909.1
1976	655.9	322.5	978.4
1977	666.8	327.8	993.4

[1] Operating expenses include the costs of feed, seed, livestock, fertilizer, hired labor, fuel, oil, and repair of buildings, vehicles, and machinery, and miscellaneous items such as insurance, irrigation expenses, costs of electricity, pesticides, veterinary services, and other expenses.

[2] Fixed expenses include depreciation on farm buildings and machinery, property taxes, interest on farm mortgages, and rent paid to non-farm landlords.

[3] Not including family and operator labor, opportunity costs (for owned capital) and management.

Source: Compiled from Fielder, Parker, and Penn, 1969, *op.cit.*, Table 6; Fielder and Guy, 1973 and 1976, *op. cit.*, Table 5; and *State Farm Income Statistics* (supplement to Statistical Bulletin No. 609), ESCS, USDA, September, 1978.

1977, more than doubling between 1968 and 1977.

Fixed expenses are costs that must be met whether or not anything is produced in a given year. For example, the note on a tractor (principle and interest) must be paid even if it is never moved from the shed; payment must be made on the hay barn even if no hay is stored in it. Fixed costs include depreciation on farm buildings, equipment, and machinery, and property taxes, interest on mortgages, and rent. Fixed expenses increased from $44.1 million in 1949 to $326.5 million in 1974 and $327.8 million in

1977. Higher land rent accounted for a major part of the increase in fixed expenses in recent years. For example, land rent increased from $17.4 million in 1971 to $100 million in 1974.

Total production ''expenses'' is normally the sum of operating and fixed expenses in a given year. It does not always include all economic costs, however. For example, in Table 8 the value of family and operator labor, ''opportunity costs'' of owned capital, and management costs are excluded.[4]

Total production expenses have increased dramatically since about 1970, to a record level of $993.4 million in 1977. This represents an increase of over 200 percent. The largest increase occurred between 1973 and 1974, largely due to higher petroleum, fertilizer, and land rental expenses. Part of the increase in production expenses is explained by higher levels of input use. A significant part of the increase in production expenses was caused by inflated prices of inputs, especially prices for gasoline, petroleum, and fertilizer in recent years.

Farm Productivity

Data thus far provides various measures of growth in Louisiana agriculture. Farms have become larger, and the value of output and input costs have increased. At the same time, farm productivity has also increased. Productivity refers to the level of output produced from a unit of input such as an acre of land or hour of labor. Data in Table 9 indicate that farm output per man-hour increased 42 percent in the Delta States (Louisiana, Arkansas, and Mississippi) between 1967 and 1975. The increase is due to new technology, higher yielding varieties, and increased use of machinery that decreases the number of man-hours required to perform various farm operations. This represents a significant increase in labor productivity and reflects more efficient production processes that have been adopted in farming. It is generally conceded that labor productivity in farming has increased more rapidly than in most of the industrial sectors of the economy. The result has been relatively low cost food and fiber for domestic consumption and export and the release of farm labor for non-farm production in other sectors of the economy.

Louisiana Crops of National Importance

Louisiana ranks among the top 10 of the 50 states in the production of sugarcane, rice, and cotton. In 1975, Louisiana harvested more acres of

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[4] ''Opportunity costs'' refer to income ''lost'' (not received) because money invested in one kind of enterprise, for example, might have earned more return in another enterprise. If an investment earns $10 when it might have earned $40 in another use, the ''opportunity cost'' is $30.

Table 9.—Index of farm output per man-hour of labor, Delta States Region, 1965-1975 (1967 = 100)*

Year	Index of farm output per man-hour
1965	90
1966	93
1967	100
1968	114
1969	112
1970	124
1971	130
1972	135
1973	137
1974	133
1975	142

*The Delta States Region includes Arkansas, Mississippi, and Louisiana.

Source: U.S. Department of Agriculture, *Agriculture Statistics,* 1976, U.S. Government Printing Office, Washington, D.C. 1976.

sugarcane for sugar (329,000 acres) than any other state. In comparison, Florida and Hawaii harvested 297,000 and 112,000 acres, respectively. Higher yields in the other cane producing states caused Louisiana to rank third in total cane production. In 1975, Louisiana produced 6.9 million tons of cane for sugar compared with 9.9 million tons for Florida and 10.4 million tons for Hawaii. Hawaii had an average yield of 92.9 tons of cane per acre, compared with 33.2 and 21.0 tons per acre for Florida and Louisiana, respectively.

In 1976, Louisiana ranked second among all states in harvested acreage of rice (568,000 acres), surpassed only by Arkansas with 847,000 acres, and followed by Texas with 508,000 acres. In total rice production, Louisiana was third behind Arkansas and Texas. In 1975, rice yields in California were almost 1,900 pounds per acre higher than in Louisiana, thus moving California ahead of Louisiana in total rice production.

In 1975, Louisiana ranked seventh among all states in cotton acreage harvested and fifth in total production of cotton. These rankings are somewhat lower than normal because, as noted earlier, acres of cotton harvested in the state in 1975 was the lowest in many years. Louisiana usually ranked about fourth or fifth among the cotton producing states.

Louisiana's Share of Crop and Livestock Marketings

Within the period 1940 to 1976, Louisiana's dollar share of agricultural marketings in the United States increased for some commodities, particularly cotton, soybeans, wheat, cattle and calves, chickens, broilers, and eggs and decreased for sugarcane, rice, oats, hay, hogs and pigs, and

Table 10.—Louisiana's dollar share of United States' marketings, by commodities, selected years, 1940, 1958, and 1976 (excludes government payments)

Commodity	1940	1958	1976
	---------(Percent of U.S.)----------------		
Sugarcane*	75.0	77.2	35.4
Rice	35.0	25.1	19.0
Cotton	3.6	2.5	5.2
Soybeans	0.5	0.5	4.1
Sweet Potatoes	7.1	16.2	10.5
Corn	1.0	4.6	0.1
Wheat	—	0.05	0.1
Sorghum	—	1.1	0.3
Oats	0.2	0.1	0.1
Hay	0.6	0.6	0.3
Cattle & Calves	0.6	1.4	1.1
Hogs & Pigs	1.0	0.5	0.4
Chickens	0.7	0.8	1.4
Broilers	—	1.1	1.8
Eggs	0.5	0.6	1.1
Dairy Products	0.9	0.8	1.0
Strawberries	10.9	7.6	1.6

*Excludes Hawaii.

Source: Agricultural Statistics (Vol. 1941, 1959, and 1977) United States Government Printing Office, Washington, D.C.

strawberries (Table 10). Others, including sweet potatoes, corn, and sorghum, reflected higher values at the midpoint of the period and then declined. Dairy products remained fairly constant over this time period.

The growing importance of Louisiana as a soybean producer is well documented in crop statistics which show that Louisiana farmers sold about $300,000 worth of soybeans in 1940 compared to over $376 million in 1976. The poultry industry is increasing in importance, as chickens, broilers, and eggs produced in Louisiana account for an increasing share of total U.S. production. The most conspicuous changes in Louisiana's share of U.S. production are the increases in soybeans and poultry products, as contrasted with the declines in shares of production of sugarcane, rice, and strawberries.

Louisiana Agricultural Exports

Because of its strategic location at the foot of the Mississippi River, Louisiana serves as a funnel for the export of about 40 million tons, or $7 billion, in agricultural exports annually. In 1974, this represented about 30 percent of total U.S. agricultural exports.

Traditionally, Louisiana thrives on foreign trade. About $2 out of every $5 received by farmers from sale of farm products results from exports.

Agricultural products originating in Louisiana accounted for about 8 percent of the agricultural exports through Louisiana ports. Of the several agricultural commodities exported, the portions contributed by Louisiana producers and processors were: 91 percent of the rice, 9 percent of the soybeans, about 52 percent of grain products (cereal by-products, oilseed cake, meal, and similar products), and 13 percent of the fats and oils.

In 1974, the farm value of agricultural exports originating in Louisiana (other than lumber) was estimated at $554.4 million or 40.6 percent of the total $1.4 billion in Louisiana farm marketings (excludes forest products, and nursery and greenhouse sales). It is estimated that the export of Louisiana farm products generated employment for about 42,000 workers and related labor incomes of $348 million.[5]

Rice and soybeans are the major crops Louisiana exports—about 80 and 90 percent of the state's production, respectively. Of the Louisiana rice and soybeans exported in 1974, about half of the rice and one-fourth of the soybeans were exported through Texas ports because of existing transportation and processing arrangements.

Louisiana is a net importer of beef, pork, and most meat products. Exports consist mainly of poultry and livestock by-products such as hides, tallow, and lard.

Complete data on the export of forestry products from Louisiana are difficult to find because of the absence of central forwarding terminals for trucking and rail lines. Nevertheless, a significant measure of the volume of wood and wood product exports is obtained from reports of waterborne commerce passing through the ports of New Orleans, Lake Charles, and Baton Rouge.[6] During the period 1954 to 1976, exports of logs and lumber ranged from a low of 35,000 tons in 1961 to a high of 200,000 tons in 1976, or an average of about 94,000 tons annually.

Exports of plywood and manufactured products declined from a high of 56,000 tons exported in 1954 to a low of 12,000 tons in 1972, then gradually increased to 39,000 tons in 1976. Exports of pulp and paper, however, have increased from about 79,000 tons in 1954 to 935,000 tons in 1976. Although the origin of these wood product shipments is not stated, it is assumed that a large share of the exports originated in Louisiana.

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[5] *Foreign Agricultural Trade and Its Importance to Louisiana,* by Floyd L. Corty and Julio C. Varela, D.A.E. #508, Department of Agricultural Economics and Agribusiness, Louisiana State University, Center for Agricultural Sciences and Rural Development, October 1976.

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[6] *Waterborne Commerce of the United States,* Part 2, Waterways and Harbors, Gulf Coast, Mississippi River System and Antilles, Department of the Army Corps of Engineers, New Orleans, Louisiana, Annual Reports.

IV. MAJOR LOUISIANA CROPS: TRENDS IN ACREAGE, YIELD, PRODUCTION, AND LOCATION OF PRODUCTION

Field Crops

Cotton

Historically, cotton has been one of the major crops in Louisiana. However, the number of harvested acres of cotton has declined considerably since 1940 (Figure 5). From 1940 to 1944, an average of 995,000 acres was harvested. In contrast, an average of only 393,000 acres was harvested from 1966 to 1970. Harvested acreage increased to an average of 538,000 acres between 1972 and 1976. Acreage harvested in 1975 (310,000) was the lowest recorded during the period. In 1977, 540,000 acres were harvested.

There was a significant increase in the yield of cotton lint per acre during the period from 1940 to 1976 (Figure 6). An average of only 268 pounds of lint per acre was produced from 1940 to 1944, compared with almost 484 pounds per acre from 1972 to 1976 and more than 600 pounds per acre in 1963, 1966, 1967, and 1968. Estimated yield for 1978 was 583 pounds. Weather conditions account for a large part of the year-to-year variation in cotton yields.

Total production of cotton lint in Louisiana varied greatly during the period (Figure 7). The lowest level of production occurred in 1949 when only 247,000 bales were harvested. On the other hand, a record high of 806,000 bales was harvested in 1953. While year-to-year variations in total production have been large, average production for the period from 1940 to 1944 at 544,000 bales was about the same as for the period from 1972 to 1976 at 537,000 bales. Production in 1977 was 656,000 bales. Increases in yields have generally been sufficient to offset the decline in acreage of cotton harvested during the last 35 years.

Significant shifts have also occurred in the location of cotton production in Louisiana. From 1940 to 1944, cotton was produced in all areas of the state, with the exception of Farming Area 9. The major cotton producing regions were Areas 2, 4, and 6, which accounted for about 75 percent of total production. Production has become more concentrated in recent years. From 1972 to 1976, Farming Areas 2 and 4 accounted for 16 and 77 percent, respectively, of Louisiana's cotton production. Farming Area 6 produced 4.5 percent of the cotton and other farming areas combined to contribute less than 7 percent of total cotton production between 1972 and 1976. Figure 8 and subsequent maps have shaded areas showing regions of specialized production. The legend indicates the percentage of total production of a particular commodity within a designated farming region.

Figure 5. Cotton Acreage Harvested, Louisiana, 1940-1976.

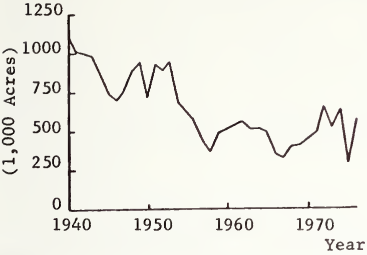


Figure 6. Cotton Yield per Acre, Louisiana, 1940-1976.

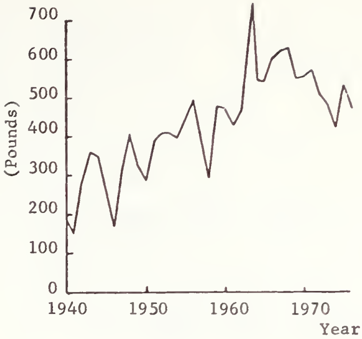


Figure 7. Total Production of Cotton, Louisiana, 1940-1976.

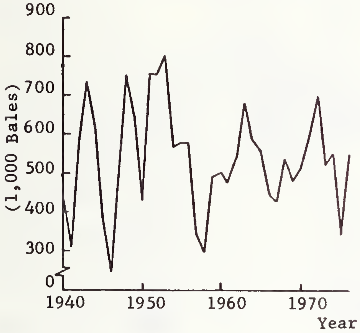
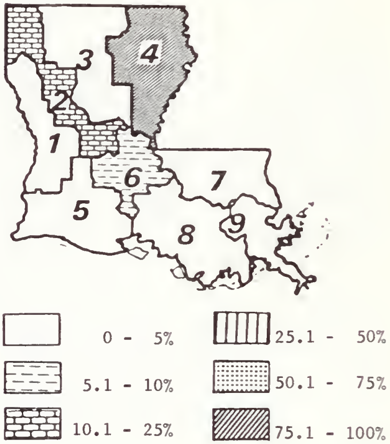


Figure 8. Concentration of Cotton Production, by Farming Area, Louisiana, 1972-1976.



Rice

Harvested acreage of rice has fluctuated between 400,000 acres and 680,000 acres since 1940 (Figure 9). During the periods 1940 to 1944 and 1972 to 1976, harvested acreage averaged 558,400 and 606,000 acres, respectively. The estimate for 1978 was 583,000 acres. Government restrictions were largely responsible for the decline in harvested acres of rice during the mid fifties. On the other hand, changes in government programs that relaxed these restrictions resulted in a significant increase in rice acreage from 1973 to 1975.

Rice yields ranged around 17 hundredweight per acre between 1940 and

Figure 9. Rice Acreage Harvested, Louisiana, 1940-1976.

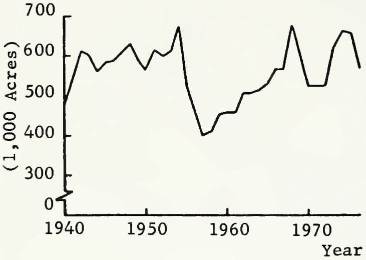


Figure 10. Rice Yield per Acre, Louisiana, 1940-1976.

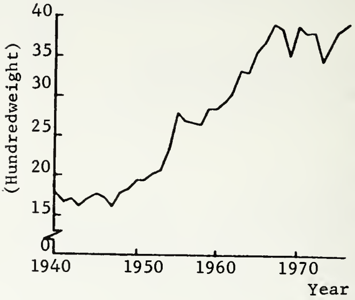


Figure 11. Total Production of Rice, Louisiana, 1940-1976.

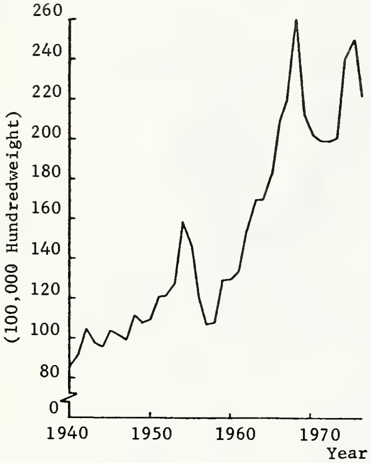
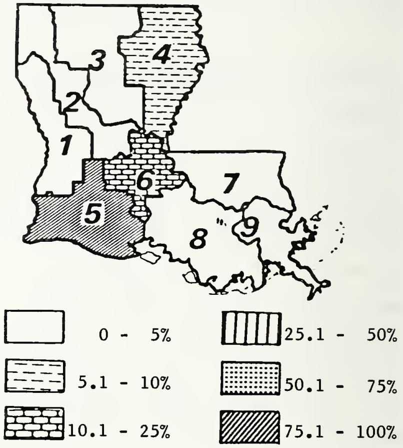


Figure 12. Concentration of Rice Production, by Farming Area, Louisiana, 1972-1976.



1947 (Figure 10). Yields per acre increased dramatically between 1948 and 1967, reaching a yield of 39 hundredweight in 1967. Rice yields generally leveled off and averaged about 37 hundredweight per acre from 1972 to 1976. The 1977 yield was 36.7 hundredweight; the estimate for 1978 was 37.0 hundredweight.

The trend in total rice production has been upward, increasing from 8.4 million hundredweight in 1940 to 25.1 million hundredweight in 1975 (Figure 11). Total production reached a record level in 1968 at 26.1 million hundredweight. Production averaged about 22.5 million hundredweight during the 5-year period from 1972 to 1976. Most of the increase in rice production is attributable to increases in yield per acre during the period. Production was 17.4 million hundredweight in 1977 and 21.6 million hundredweight was estimated for 1978.

Rice production has traditionally been concentrated in Farming Area 5, the southwestern part of the state (Figure 12). This is largely due to the impervious subsoils of southwest Louisiana that are used to hold irrigation water to discourage weeds during the growing period. Farming Area 5 accounted for an average of almost 83 percent of the rice produced in the state from 1940 to 1944. Parishes in Farming Area 6, which border on the rice area, contributed about 10 percent of total production.

Farming Areas 5 and 6 still account for the major portion of total rice production, 76 and 15 percent, respectively, from 1972 to 1976. However, production has been expanding in Farming Area 4 in northeast Louisiana in recent years. The area accounted for almost 10 percent of total production in 1975. Parts of the area are well-suited for rice production, and recent changes in government programs have encouraged farmers to expand production.

Sugarcane

Sugarcane, like cotton, has a long economic history in Louisiana. Harvested acreage has fluctuated substantially over the years, averaging 266,200 acres between 1940 and 1944 and increasing to 330,000 acres from 1972 to 1976 (Figure 13). This represents a 24 percent increase in acreage. From 1940 to 1976, sugarcane acreage varied between a low of 222,000 acres in 1956 and a high of 345,000 acres in 1964. It was 322,000 acres in 1977 and was estimated at 300,000 acres for 1978.

Sugarcane yields have increased slightly over time (Figure 14). Yields averaged 18.0 tons and 22.8 tons per acre from 1940 to 1944 and 1972 to 1976, respectively. The highest yield during the period was 29.0 tons per acre in 1963; the lowest yield occurred in 1940 when only 13.9 tons per acre were produced. The 1977 yield was 23.9 tons per acre, and 22 tons were estimated for 1978.

Total production of sugarcane increased about 56 percent between the periods 1940 to 1944 and 1972 to 1976 (Figure 15). The increase was due both to more acreage and higher yields. Production from 1940 to 1944 averaged 4.8 million tons, compared with 7.5 million tons from 1972 to 1976. Total production in Louisiana peaked in 1963 at almost 9.2 million tons of sugarcane. Production during the period from 1940 to 1976 was lowest in 1940 when only 3.35 million tons were produced. The 1977 production was 7.7 million tons, and 6.6 million tons was estimated for 1978.

Ninety percent of the sugarcane production in Louisiana between 1972 and 1976 was concentrated in Farming Area 8, the Sugarcane Area (Figure 16). This percentage has remained relatively constant over time. The only other area that produced a significant amount of sugarcane is the Central

Figure 13. Sugar Cane Acreage Harvested, Louisiana, 1940-1976.

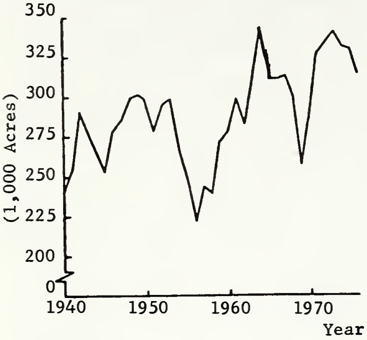


Figure 14. Sugar Cane Yield per Acre, Louisiana, 1940-1976.

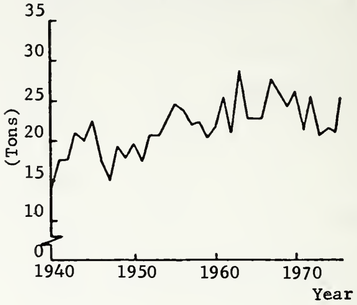


Figure 15. Total Production of Sugar Cane, Louisiana, 1940-1976.

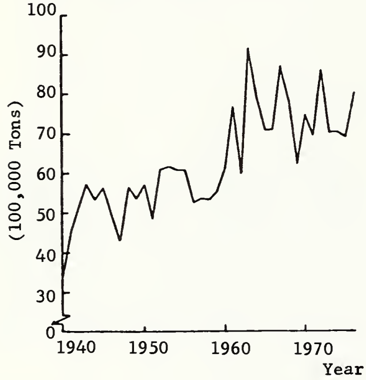
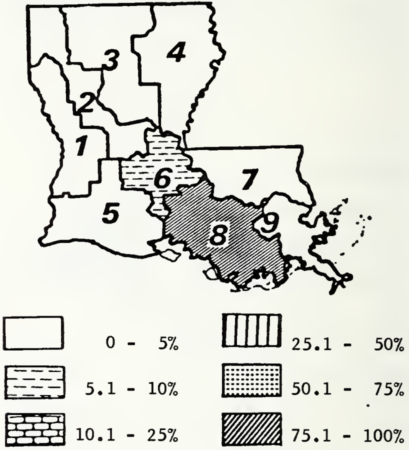


Figure 16. Concentration of Sugar Cane Production, by Farming Area, Louisiana, 1972-1976.



Louisiana Mixed Farming Area (Area 6) which has consistently accounted for about 7 percent of total production. Parishes in other farming areas that border on Farming Area 8 also produce small amounts of sugarcane.

Soybeans

The soybean, grown in nearly every farming area, is Louisiana's miracle crop. Harvested acreage of soybeans was very small prior to 1950, averaging only 31,800 acres from 1940 to 1944 and reaching 50,000 acres in 1952 (Figure 17). Moderate increases in acreage occurred between 1950 and 1962, followed by a dramatic increase beginning in 1962. Harvested acreage of soybeans increased from 200,000 acres to almost 1.7 million acres by 1970. Average acreage between 1972 and 1976 was 1.8 million acres, with 2.3 million acres harvested in 1976. Soybeans now rank as the number one crop in Louisiana, with a planted acreage of 2.9 million acres estimated for 1978.

Figure 17. Soybean Acreage Harvested, Louisiana, 1940-1976.

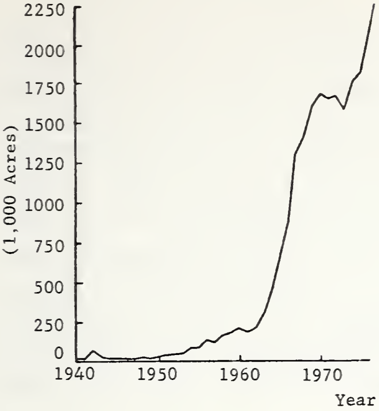


Figure 18. Soybean Yield per Acre, Louisiana, 1940-1976.

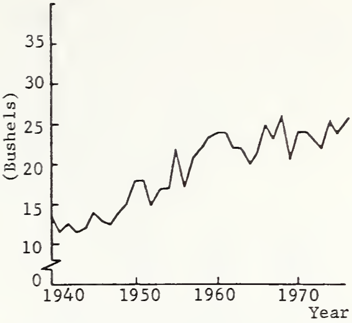


Figure 19. Total Production of Soybeans, Louisiana, 1940-1976.

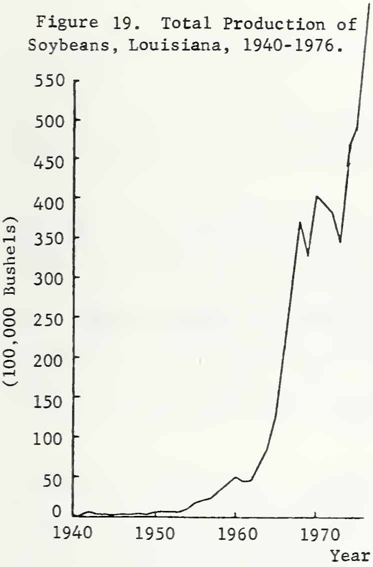
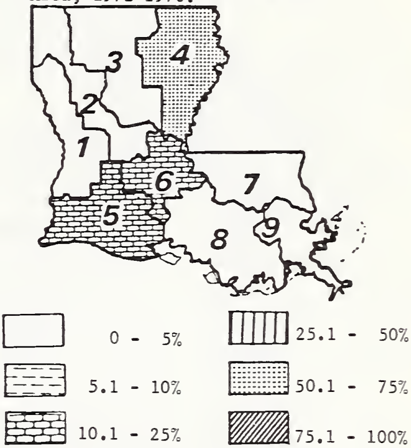


Figure 20. Concentration of Soybean Production, by Farming Area, 1972-1976.



Soybean yields have almost doubled since 1941 (Figure 18). Yields averaged 12.2 bushels per acre from 1940 to 1944 and 25.1 bushels per acre from 1972 to 1976. The highest yield for Louisiana occurred in 1968 and 1976 when 28 bushels per acre were harvested. Estimated yield for 1978 is 24 bushels per acre.

The increase in yields and acreage of soybeans had a dramatic effect on total production, which averaged only 388,000 bushels from 1940 to 1944 compared to 46.5 million bushels for the period from 1972 to 1976, with a high of 63.0 million bushels produced in 1976 (Figure 19). Total production increased over 900 percent between 1962 and 1970, a period of major expansion in soybean acreage in Louisiana. Estimated production for 1978 is 70.8 million bushels.

The major soybean producing regions between 1972 and 1976 were Farming Areas 4, 5, and 6 (Figure 20). Farming Area 4 was the leading production area, accounting for about 54 percent of total production during the recent 5-year period. This was a decrease in the relative share of soybean production as compared to over 80 percent of the total production between 1955 and 1959. Farming Areas 5 and 6 accounted for 18.9 and 17.6 percent, respectively, of the total production between 1972 and 1976. Both areas have increased their relative share of total production since 1955. An average of 21.4 percent and 19.1 percent of Louisiana's soybeans were produced in Areas 5 and 6, respectively, in 1977. Other farming areas accounted for less than 5 percent of the soybeans grown in the state between 1972 and 1976. Soybean acreage has been increasing in other parts of the state, particularly in Areas 2 and 8.

Corn for Grain

Most of the corn grown in Louisiana is harvested for grain. However, some corn is used for silage. Since the importance of the latter is small compared to the former, only the corn harvested for grain will be considered here.

Harvested acreage of corn for grain has declined steadily since 1940 (Figure 21). An average of 1.3 million acres was harvested from 1940 to 1944 compared with an average of 74,000 acres between 1972 and 1976. The decline in corn acreage has been gradual with no large changes in any given year. However, corn acreage in the 1970's was only about 6 percent of the acreage harvested in the early 1940's when corn was used to feed the large horse and mule population. The acreage in 1977 was 77,000 with an estimate of 50,000 acres for 1978.

Yields per acre of corn in Louisiana increased more than 300 percent between 1940 and 1976 (Figure 22). Yields averaged 15.2 bushels per acre from 1940 to 1944, compared with 51.8 bushels per acre from 1972 to 1976. Prior to 1955, year-to-year increases in yields were relatively small. Moderate although somewhat variable increases in corn yields were recorded between 1956 and 1968. Yields also increased significantly in 1976; they were estimated at 52 bushels per acre in 1977 and 58 bushels in 1978.

Increases in yields have not been large enough to offset the decrease in harvested acreage of corn. This has resulted in a decrease in the total quantity of corn produced in Louisiana (Figure 23). Total production averaged almost 20 million bushels between 1940 and 1944. An average of only 3.2 million bushels was produced from 1972 to 1976, and 3.4 million bushels were produced in 1977.

Corn is grown in practically every parish in Louisiana. Farming Area 6 accounted for the largest percentage (36 percent) of production from 1972

Figure 21. Corn for Grain Acreage Harvested, Louisiana, 1940-1976.

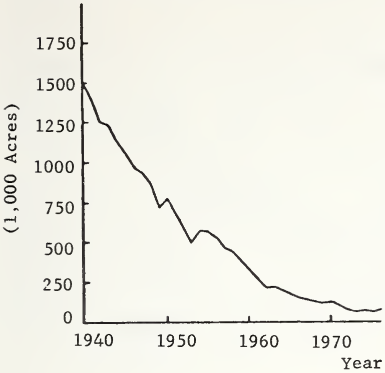


Figure 22. Corn for Grain Yield per Acre, Louisiana, 1940-1976.

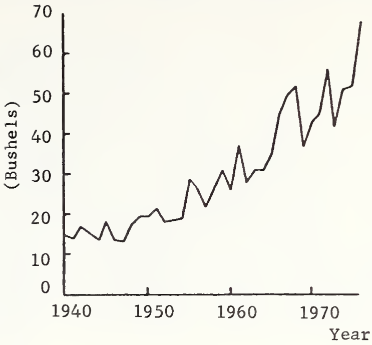


Figure 23. Total Production of Corn for Grain, Louisiana, 1940-1976.

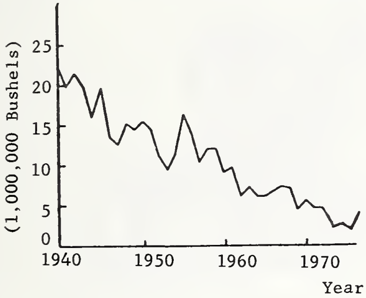
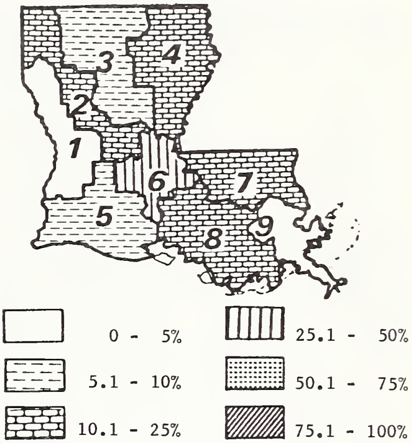


Figure 24. Concentration of Corn for Grain Production, by Farming Area, Louisiana, 1972-1976.



to 1976 (Figure 24). That area has increased its share of production over time. Farming Area 4 produced about 15 percent between 1972 and 1977; however, its relative share of total production has declined by about 50 percent since 1940-1944, while most of the other farming areas have maintained their relative share of corn production.

All Hay

Harvested hay acreage in Louisiana has exhibited several trends since 1940 (Figure 25). Acreage generally decreased between 1940 and 1948; however, the decline was followed by a major increase from 294,000 acres in 1948 to 435,000 in 1953. There was another general downward trend in acreage between 1953 and 1963. Acreage peaked in 1964 at 457,000 acres harvested. Hay acreage was reasonably stable from 1967 through 1976,

Figure 25. Hay Acreage Harvested, Louisiana, 1940-1976.

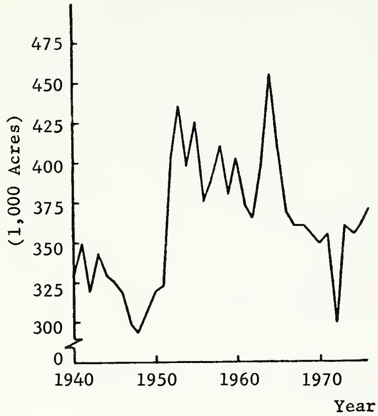


Figure 26. Hay Yield per Acre, Louisiana, 1940-1976.

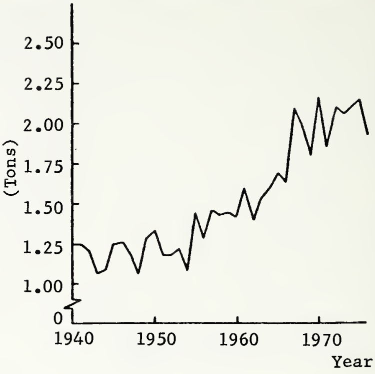


Figure 27. Total Production of Hay, Louisiana, 1940-1976.

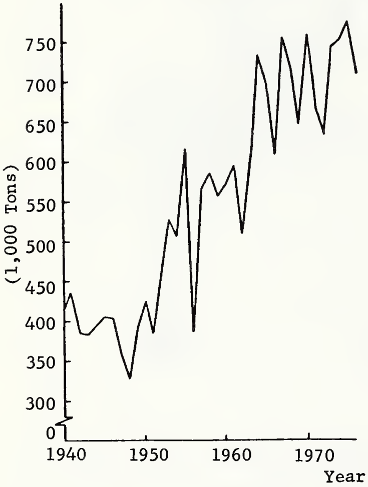
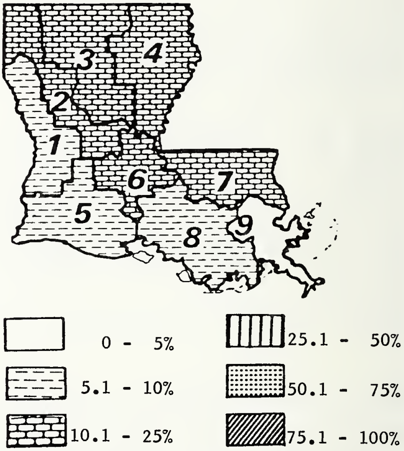


Figure 28. Concentration of Hay Acreage, by Farming Area, Louisiana, 1974.



with the exception of 1972, and averaged 352,000 acres between 1972 and 1976. It was 375,000 acres in 1977 and estimated at 360,000 acres in 1978.

Yields per acre for hay increased from an average of 1.2 tons between 1940 and 1944 to 2.0 tons for 1972-1976 (Figure 26). Yields increased more rapidly after 1961. The highest yield recorded was 2.17 tons per acre in 1970; the lowest yield during the period, 1.12 tons per acre, occurred in 1948. The 1977 yield was 1.91 tons, and a similar yield was estimated for 1978.

There was a significant upward trend in hay production after 1948

(Figure 27). Total production averaged 402,600 tons from 1940 to 1944, compared with 703,000 from 1972 to 1976. Hay production also shows very large year-to-year variations, due mainly to variations in harvested acreage. Production during the period peaked in 1975 when 738,000 tons were harvested. The lowest recorded production during the period was 329,000 tons in 1948. The 1977 production was 715,000 tons.

Hay is grown in all nine farming areas in Louisiana (Figure 28). Areas 2 and 7 were leading areas in 1974, accounting for 18.8 percent and 23.2 percent, respectively, of the state's total acreage. Farming Areas 3, 4, and 6 each accounted for more than 10 percent of the total acreage. Farming Areas 1, 3, and 4 have increased their relative share of total hay production in recent years.

Wheat

Wheat is a minor crop in Louisiana. Statistics pertaining to wheat production in Louisiana were not collected prior to 1955. From 1955 to 1959, harvested acreage averaged 42,600 acres (Figure 29). In 1967, wheat harvested acreage reached a peak of 100,000 acres. Acreage was between 25,000 and 50,000 acres during most subsequent years and averaged 21,000 acres between 1972 and 1976. The 1977 acreage was 27,000 acres, and 20,000 acres was estimated for 1978.

Wheat yields increased about 25 percent between 1955 and 1976 (Figure 30). The average yield between 1955 and 1959 was 18.2 bushels compared with an average of 22.8 bushels between 1972 and 1976. In 1976, wheat yield reached 33 bushels per acre in Louisiana for the first time. Yields were 34 bushels in 1977 and estimated at 32 bushels for 1978.

Total production peaked at 2.6 million bushels in 1967 (Figure 31). Average production between 1972 and 1976 was about 33 percent less than between 1955 and 1959 (491,000 bushels versus 733,000 bushels, respectively). Yield increases have not been large enough to offset the decrease in harvested acreage.

Sixty percent of Louisiana's wheat was produced in Farming Area 4 from 1972 to 1976 (Figure 32). The Red River Area (Farming Area 2) produced an average of about 17 percent while Farming Area 8 accounted for about 9 percent of Louisiana's production. The other farming areas accounted for less than 5 percent each of the production during this period.

Grain Sorghum

Grain sorghum is also a relatively minor crop in Louisiana. Like wheat, sorghum is produced primarily for livestock rather than as a cash crop. Harvested acreage of grain sorghum in Louisiana was very small prior to 1966 (Figure 33). From 1940 to 1944 harvested acreage was never more than 4,000 acres. Between 1955 and 1956, harvested acreage was above

Figure 29. Wheat Acreage Harvested, Louisiana, 1950-1976.

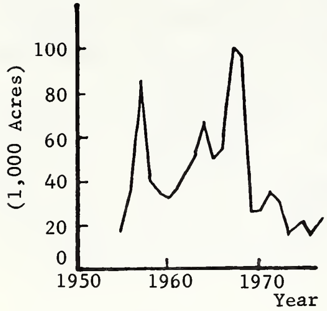


Figure 30. Wheat Yield per Acre, Louisiana, 1950-1976.

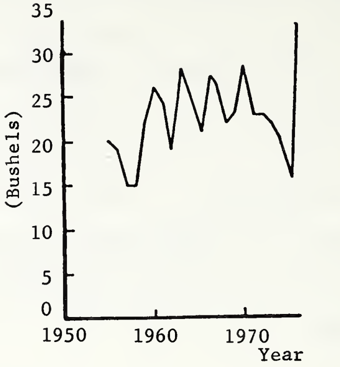


Figure 31. Total Production of Wheat, Louisiana, 1950-1976.

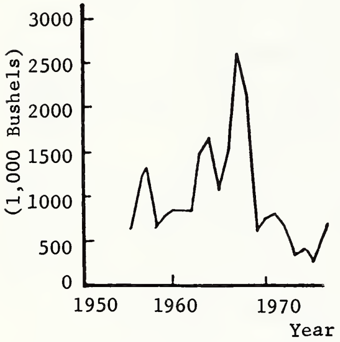
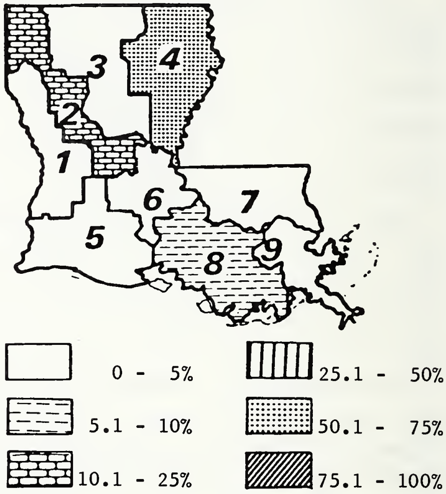


Figure 32. Concentration of Wheat Production, by Farming Area, Louisiana, 1972-1976.



10,000 acres in only 2 years, 1955 and 1958. Acreage increased significantly after 1966 and reached a peak in 1970 when 80,000 acres were harvested. During the period 1972 to 1976, the average declined to 23,000 acres. The 1977 acreage was 20,000, and the 1978 estimate was 16,000.

Grain sorghum yields increased about 120 percent from 1940 to 1976 (Figure 34). The average yield between 1940 and 1944 was 15.8 bushels per acre, compared with 34.4 bushels between 1972 and 1976. The highest yields occurred in 1968, with an average of 40 bushels per acre. The 1977 yield was 33 bushels; 31 bushels was the estimated 1978 yield.

Figure 33. Sorghum Acreage Harvested, Louisiana, 1940-1976.

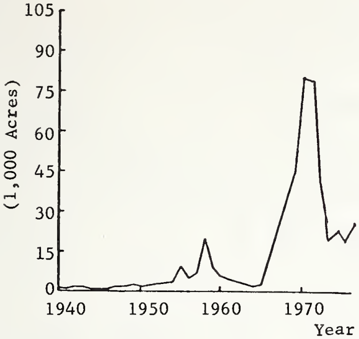


Figure 34. Sorghum Yield per Acre, Louisiana, 1940-1976.

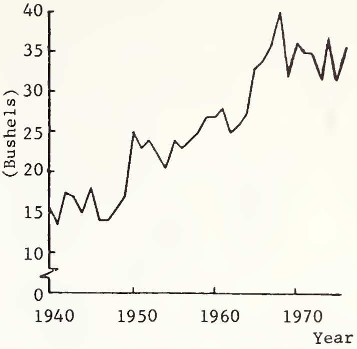


Figure 35. Total Production of Sorghum, 1940-1976.

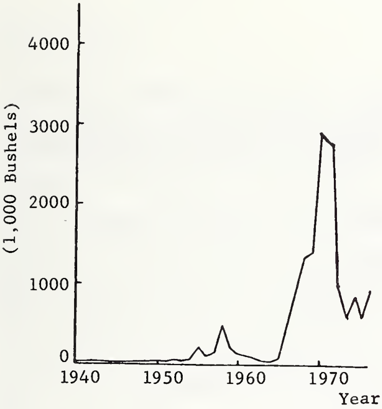
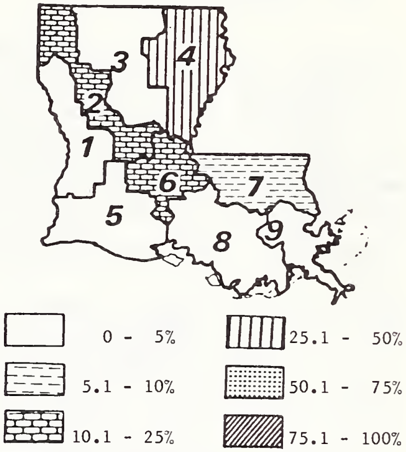


Figure 36. Concentration of Sorghum Production, by Farming Area, Louisiana, 1972-1976.



Total production of grain sorghum has increased in Louisiana, as a result of expanded acreage and higher yields (Figure 35). Production averaged 15,800 bushels from 1940 to 1944 and 795,000 bushels from 1972 to 1976. Production peaked in 1970 at 2.88 million bushels of grain sorghum. The 1977 production was 660,000 bushels, and the estimate for 1978 was 496,000 bushels.

Sorghum production has been concentrated in Farming Areas 2, 4, and 6 (Figure 36). These are also areas of concentration for beef cattle (see Figure 60). These three areas accounted for almost 85 percent of sorghum production in Louisiana from 1972 to 1976. The only other area that produced more than 5 percent of the total production was Farming Area 7.

Figure 37. Oat Acreage Harvested, Louisiana, 1940-1976.

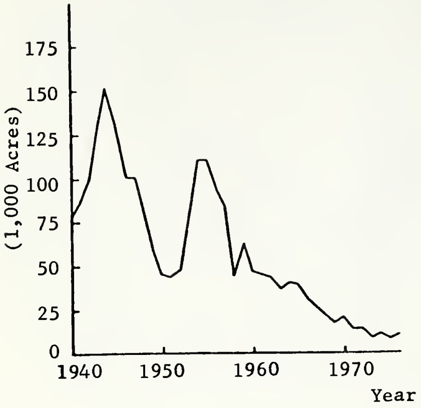


Figure 38. Oat Yield per Acre, Louisiana, 1940-1976.

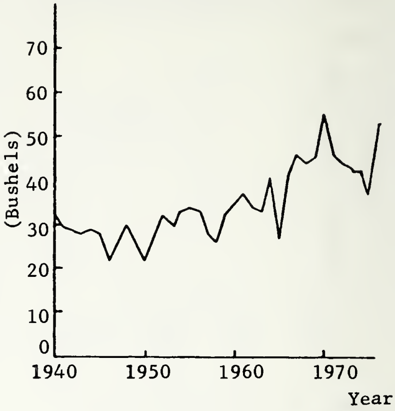


Figure 39. Total Production of Oats, Louisiana, 1940-1976.

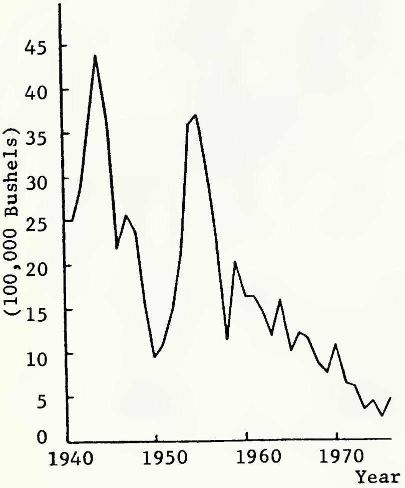
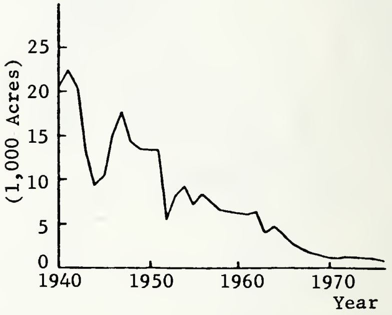


Figure 40. Strawberry Acreage Harvested, Louisiana, 1940-1976.



Oats

Harvested acreage of oats in Louisiana varied considerably during the last 36 years (Figure 37). Acreage almost doubled between 1940 and 1944, peaking at a record of 152,000 acres in 1944 then declining to 43,000 acres in 1951 before recovering to 110,000 acres in 1954 and 1955. Acreage has declined steadily since 1955, and only 12,000 acres of oats were harvested in 1972. An average of 8,400 acres was harvested in the period 1972 to 1976, compared with an average of 109,600 acres between 1940 and 1944.

Oat yields increased about 25 percent during the period under analysis (Figure 38). Yields per acre averaged 29.6 bushels per acre and 43.8 bushels per acre between 1940 and 1944 and 1972 and 1976, respectively. A record yield of 55 bushels was attained for Louisiana in 1970.

The trend in total production of oats in Louisiana primarily reflects changes that occurred in harvested acreage (Figure 39). Total production peaked in 1944, when slightly more than 4.4 million bushels were produced. On the other hand, only 264,000 bushels were produced in 1975. Total production averaged 3.2 million bushels between 1940 and 1944, compared with only 426,000 bushels between 1972 and 1976.

Detailed information is not available for the location of production of oats in Louisiana. Historically, Farming Areas 2, 4, 5, and 7 have been the major oat producing regions. Farming Area 4 is probably the leading area for oat production in Louisiana.

Strawberries

The harvested acreage of strawberries has also declined since 1940 (Figure 40). Over 20,000 acres were harvested each year between 1940 and 1942. After that period, acreage declined steadily until 1970 when it leveled off at about 1,100 acres. Considerable yearly variations in harvested acreage occurred prior to 1955. Louisiana strawberries are produced primarily for the fresh market. The mild climate results in early maturing, and the berries must compete with those produced early in other areas. In 1977, 850,000 acres were harvested.

Strawberry yields per acre more than tripled between 1940 and 1976 (Figure 41). Yields increased from 20.6 hundredweight between 1940 and 1944 to 65.2 hundredweight between 1972 and 1976. Most of the increase in yields occurred between 1963 and 1971; a record yield of 74 hundredweight per acre was achieved in 1971. The yield per acre in 1977 was 61 hundredweight. Climatic conditions account for a major part of the year-to-year variations in yields.

Total production declined during the period because of the large decrease in harvested acreage (Figure 42). Yield increases only partially offset acreage reductions. Total production peaked in 1942 at 553,700 hundredweight and fell to an average of 62,800 hundredweight between 1972 and 1976. The lowest production year between 1940 and 1976 was 1974 when 55,000 hundredweight of strawberries were produced. The 1977 production was 52,000 hundredweight.

Nearly all of Louisiana's strawberries are produced in Farming Area 7, particularly in Livingston and Tangipahoa Parishes. In earlier years many were picked one day, shipped overnight to the Chicago area, and marketed there the following day.

Strawberries are a labor intensive crop in Louisiana, produced on small

Figure 41. Strawberry Yield per Acre, Louisiana, 1940-1976.

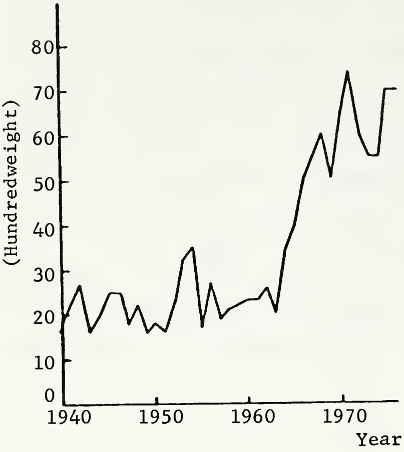
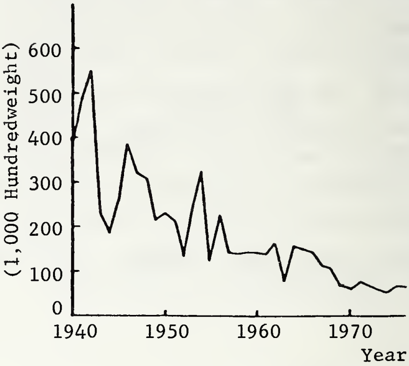


Figure 42. Total Production of Strawberries, Louisiana, 1940-1976.



farms with large families and using primarily family labor. Over the years alternate off-farm employment made labor difficult to obtain. Competition from areas producing on large farms, such as Florida, Texas, and Mexico, also contributed to the decline in acreage and production in Louisiana.

Sweet Potatoes

Except for the period between 1940 and 1946, harvested acreage of sweet potatoes generally declined between 1940 and 1976 (Figure 43). Harvested acreage averaged 97,600 acres between 1940 and 1944 and peaked at 125,000 acres in 1946. An average of only 32,000 acres was harvested between 1972 and 1976. The lowest acreage recorded during the period was 29,000 acres in 1976. The 1977 acreage was 27,000 acres and the same acreage was estimated for 1978.

Per acre yields of sweet potatoes doubled between 1940 and 1976 (Figure 44). Yields averaged 45.4 hundredweight for the 5-year period from 1940 to 1944 and increased to an average of 97.0 hundredweight for the period from 1972 to 1976. A record yield of 105 hundredweight per acre was recorded in 1974. The lowest yield during the period was 32 hundredweight in 1940. The yield for 1977 was 90 hundredweight, and 95 hundredweight was the 1978 estimate. Total production generally declined after 1945 as increases in yields were not large enough to offset the decline in acreage of sweet potatoes (Figure 45). Production averaged 4.4 million hundredweight and 3.1 million hundredweight for the periods 1940 to 1944 and 1972 to 1976, respectively. The highest level of total production occurred in 1945 when 6.7 million hundredweight of sweet potatoes were produced in Louisiana. 1977's production was 2.4 million hundredweight, and the 1978 estimate was 2.5 million hundredweight.

According to the 1974 Census of Agriculture, over 70 percent of the sweet potato acreage in Louisiana was in Farming Area 6 (Figure 46). Farming Areas 4, 5, 7, and 8 each accounted for between 4 and 10 percent of the acreage.

Irish Potatoes

Irish potatoes have never been a major crop in Louisiana. Harvested acreage of Irish potatoes declined dramatically between 1944 and 1960 (Figure 47). Acreage peaked in 1944 at 59,000 acres and declined to 2,300 acres in 1973. Acreage remained relatively stable after 1960. It averaged 2,600 acres for the period from 1972 to 1976, and 2,300 acres in 1977 and 1978.

Like sweet potatoes, the yield per acre of Irish potatoes doubled between

Figure 43. Sweet Potato Acreage Harvested, Louisiana, 1940-1976.

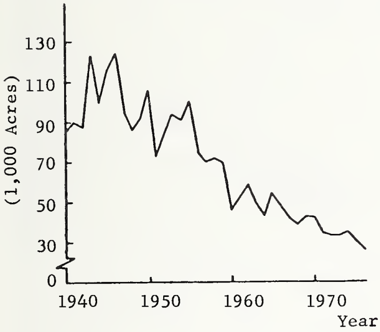


Figure 44. Sweet Potato Yield per Acre, Louisiana, 1940-1976.

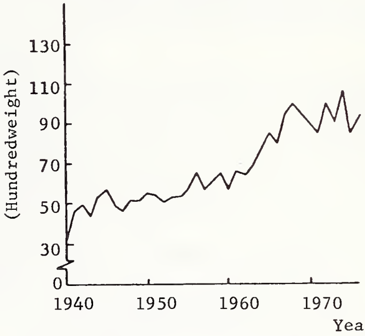


Figure 45. Total Production of Sweet Potatoes, Louisiana, 1940-1976.

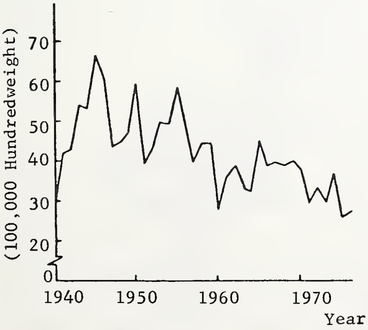
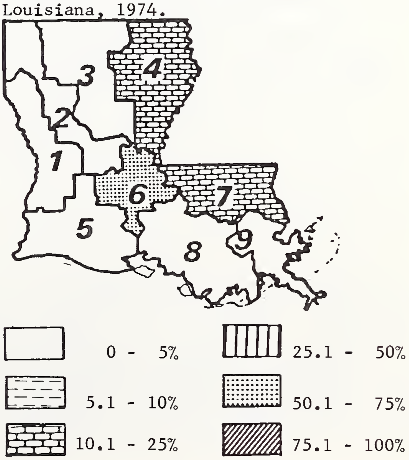


Figure 46. Concentration of Sweet Potato Acreage, by Farming Area, Louisiana, 1974.



1940 and 1976 (Figure 48). Yields averaged 35.6 hundredweight between 1940 and 1944, and 78.6 hundredweight between 1972 and 1976. The estimate for 1977 and 1978 was 75 hundredweight per acre.

Total production of Irish potatoes declined after 1944, reflecting the decrease in harvested acreage (Figure 49). Production averaged 1.7 million hundredweight between 1940 and 1944. In comparison, total production declined to an average of only 204,600 hundredweight between 1972 and 1976. The best year, in terms of total production, was 1943 when over 2.1 million hundredweight were produced. The estimate for both 1977 and 1978 was 173,000 hundredweight.

Irish potatoes are grown in all farming areas except Farming Area 9 (Figure 50). According to Census of Agriculture data Areas 6 and 7 accounted for over 60 percent of the acreage in 1974. In addition, Farming Areas 3, 4, and 8 each contained about 10 percent of the total acreage.

Figure 47. Irish Potato Acreage Harvested, Louisiana, 1940-1976.

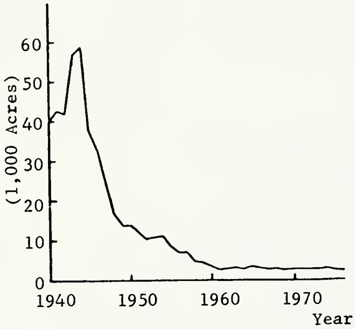


Figure 48. Irish Potato Yield per Acre, Louisiana, 1940-1976.

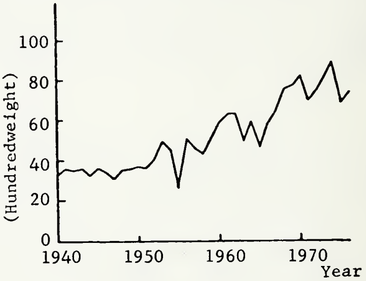


Figure 49. Total Production of Irish Potatoes, Louisiana, 1940-1976.

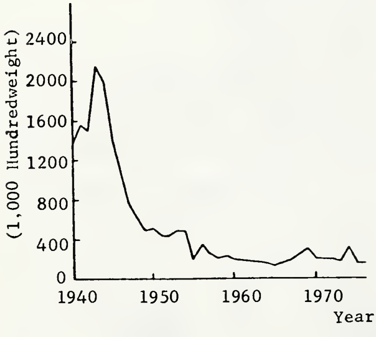
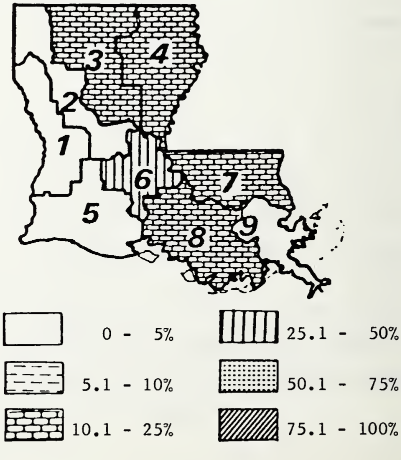


Figure 50. Concentration of Irish Potato Acreage, by Farming Area, Louisiana, 1974.



Vegetables

Many different types of truck crops are grown on Louisiana farms. However, commercial acreages of many declined over the years to the point that the Statistical Reporting Service, USDA, ceased reporting data on many of them. For example, Louisiana shallots (a small bulb onion sold in bunches) are now grown in relatively small quantities and no longer reported in official data. Thus, quantitative data are available only for watermelons, tomatoes, winter cabbage, spring snapbeans, and green peppers, and these will be discussed in this section.

Harvested acreage of the five vegetables still reported generally declined from 1940 to 1975 (Figure 51), peaking at 26,300 acres in 1946. In contrast, an annual average of only 6,940 acres was harvested between 1971 annd 1975. Annual harvested acreage was less than 10,000 acres after 1962. Most of the decline was due to decreased acreage of watermelons, tomatoes, cabbage, and snapbeans. Harvested acreage of green peppers was relatively stable during the time period.

Yields of these five truck crops increased about 42 percent during the period under consideration (Figure 52), averaging 53 hundredweight per acre between 1940 and 1944 and 72 hundredweight for the period from 1971 to 1975. Most of the increase was due to improved yields for tomatoes, winter cabbage, and snapbeans.

Commercial production of the five vegetables declined about 60 percent during the period (Figure 53). Increases in yields were not sufficient to offset decreases in acreage. Production peaked at 1.5 million hundredweight in 1944, but was below 1 million hundredweight every year after 1954. An average of only 512,000 hundredweight was produced between 1971 and 1975. Like strawberries, vegetable production in Louisiana has been a labor-intensive activity, and uncertain labor supplies and competition from other areas have been largely responsible for the decline in vegetable acreage and production in Louisiana.

Detailed data are not available on the location of vegetable production in Louisiana. Vegetables are grown in all farming areas, with Areas 6, 7, 8, and 9 accounting for a major share of the production. Because of their perishable nature and high transportation costs, commercial vegetables are generally produced near the larger metropolitan areas in the state.

Other Vegetables

Other important vegetables grown in Louisiana include cucumbers, shallots, okra, onions, garlic, eggplant, spinach, hot peppers, and sweet corn. They are grown primarily for the local fresh vegetable markets and some processing in the state. Large quantities of vegetables are marketed through farmers' markets that have been organized throughout the state.

Figure 51. Acreage of Five Vegetables, Louisiana, 1940-1975. (Five reported) 1/

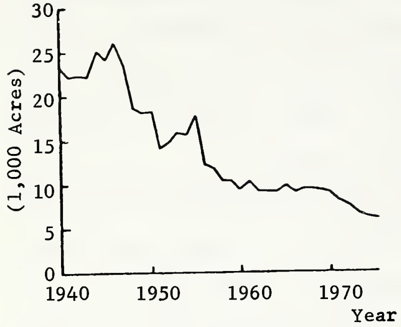


Figure 52. Vegetable Yield per Acre, Louisiana, 1940-1975.1/

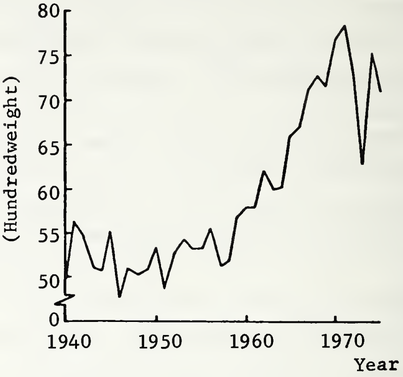


Figure 53. Production of Five Vegetables, Louisiana, 1940-1975.

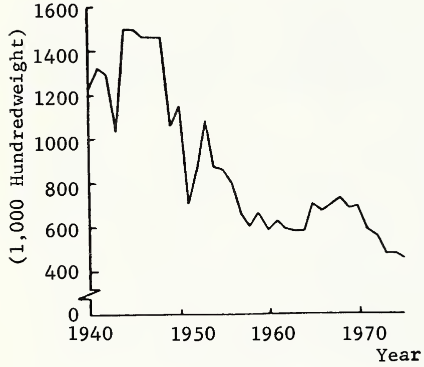
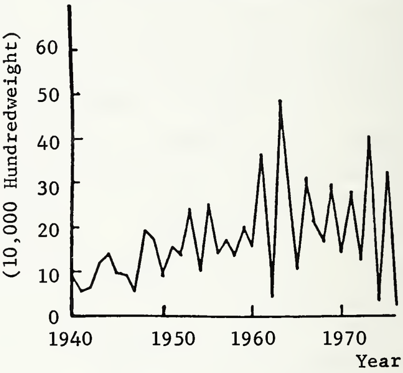


Figure 54. Total Production of Pecans, Louisiana, 1940-1976.1/



1/Watermelons, tomatoes, winter cabbage, spring snapbeans and green peppers only, as currently reported by the Statistical Reporting Service, USDA.

Although acreage and production data are not available, the U.S. Department of Agriculture estimated the value of these vegetables in 1975 was more than $5 million.

Fruits and Tree Nuts

Pecans

Pecans are native to Louisiana, and a major share of the total production is attributable to wild or native seedling varieties. However, improved varieties, more resistant to disease, have been developed by the Louisiana

Agricultural Experiment Station and production from the improved varieties is increasing.

Reported commercial pecan production almost doubled between 1940 and 1976 (Figure 54). Production averaged 9.4 million pounds per year from 1940 to 1944, compared with 17.8 million between 1972 and 1976. Commercial production reached a peak of almost 50 million pounds in 1963. Yearly variations in production have been very large, however, due to the 2-year cyclical nature of production. Trees usually bear a large crop about every other year rather than every year. The 1977 production was 31 million pounds, and the 1978 estimate was 13 million pounds.

The Red River Area (Farming Area 2), with a number of large pecan orchards, is the leading commercial production area in Louisiana. Other areas, especially Farming Areas 4, 5, and 6 also account for a significant part of production. Data are not available to provide more exact information on the location of pecan production in Louisiana.

Peaches

Commercial peach production in Louisiana declined considerably between 1940 and 1950 (Figure 55). Only 50,000 bushels were produced in 1950 compared with over 350,000 bushels in 1940. After 1950, production recovered somewhat and has been between 100,000 and 150,000 bushels in most years. An average of 127,200 bushels was produced from 1972 to 1976. In 1977, 135,000 bushels were harvested.

Although location of production data are not available, Farming Area 3 traditionally has been the state's major commercial peach production area. Peaches are also grown in Farming Areas 4 and 7.

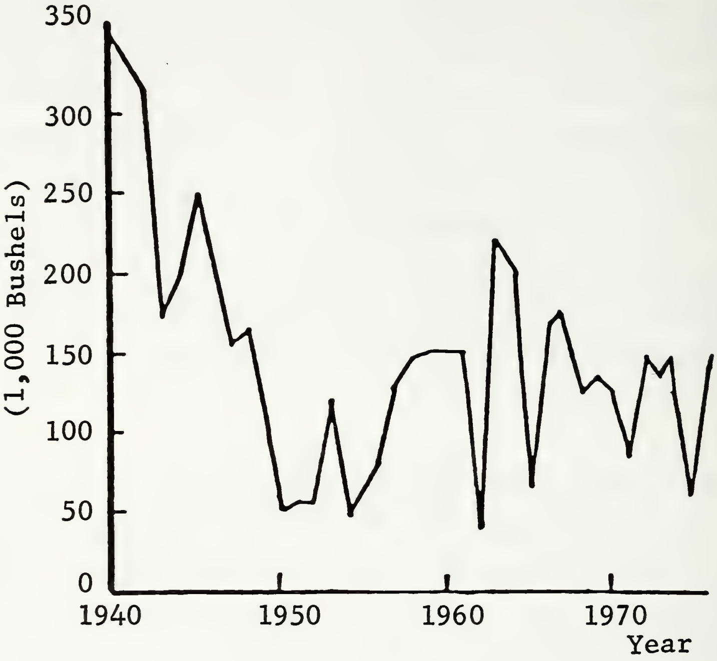
Other Fruits and Nuts

Oranges. Although data are not available on current commercial orange production levels, an average of about 277,000 boxes was harvested from 1940 to 1944. Production peaked at 410,000 boxes in 1946 and decreased rapidly after that. In 1964, the last year for which production data are available, only 8,000 boxes of oranges were harvested.

Almost all of the orange production in Louisiana occurs in Farming Area 9, beside the Mississippi River, particularly Plaquemines Parish. A frost-free climate is required for citrus production, and Plaquemines Parish, the southernmost area of Louisiana which extends into the Gulf of Mexico, comes closest to fulfulling this requirement. Occasional frosts and hurricanes have hampered the development of the citrus industry in Louisiana.

Tung Nuts. Louisiana also has a small, rapidly fading, tung nut industry. The nuts are valued for their oil which is used in paints, varnishes, and other products because it forms a water tight seal. An average of about 3,500 tons of nuts per year were harvested from 1940 to 1944. Production

Figure 55. Total Production of Peaches, Louisiana, 1960-1976.



peaked in 1952 when over 30,000 tons were harvested. Production declined after 1952, and in 1969 only 1,400 tons were harvested. Production data are not available for later years. Virtually all the tung nuts are produced in Farming Area 7, especially Tangipahoa, St. Tammany, and Washington Parishes.

Nursery and Greenhouse Products

A 1977 study indicated a total of 3,843 acres of nursery stock in Louisiana in 1977.[7] This acreage involved some 49 parishes. Most of the acreage (87 percent) is concentrated in six parishes—St. Tammany, Tangipahoa, Washington, Rapides, Lafayette, and St. Landry.

The nursery industry has become an increasingly important segment of Louisiana's economy. In 1977 there were 874 certified nurserymen in the state. The value of sales of nursery and greenhouse products at the grower level totaled almost $8 million for 1977. As a source of farm income these crops rank sixth among all crops and second among horticultural crops grown in the state.

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[7] Law, Jerry M., "Economic Importance of Louisiana's Nursery Industry," *Louisiana Rural Economist,* Volume 40, No. 3, August 1978.

The economic importance of the nursery industry in Louisiana is also reflected in the activities of numerous agribusiness firms which serve the input and marketing needs of the state's nurserymen. In 1977 there were 2,856 separate places of business in Louisiana, beyond the grower level, engaged in handling nursery products and offering services involving nursery products. Approximately half held dealer permits to sell potted plants and nursery stock. The remaining businesses included retail florists, horticultural service firms, landscape contractors, tree surgeons, and wholesale florists. These firms had individuals qualified to hold licenses issued by the Horticulture Commission of Louisiana.

V. LOUISIANA LIVESTOCK: TRENDS IN NUMBERS, PRODUCTION, AND LOCATION OF PRODUCTION

All Cattle and Calves

There was a general increase in the number of cattle and calves in Louisiana between 1940 and 1976 (Figure 56). Between 1940 and 1944 cattle numbers averaged 1.3 million head, compared to 1.8 million head for the period from 1972 to 1976. The number of cattle and calves increased dramatically from 1950 to 1954, indicating that the livestock industry of Louisiana grew substantially during that period.

Several cycles in the number of cattle and calves in Louisiana can be identified. Cycle peaks occurred in 1945, 1954, and 1965. The number of cattle and calves reached a record level of 1.98 million head in 1965. Cattle numbers increased from 1.6 million head in 1971 to 1.8 million head in 1976 but declined to 1.7 million head in 1977.

The increase in cattle numbers has been accompanied by a general increase in the production (pounds) of cattle and calves (Figure 57). During the period 1940-1944, an average of 181.5 million pounds were produced. Production increased to an average of 501.6 million pounds for the years 1972 to 1976. Total production reached an all-time high in 1972 when 547.1 million pounds were produced. Production was 467.7 million pounds in 1977. A major expansion in cattle production occurred between 1949 and 1955, reflecting the large increase in cattle numbers during that period.

Cattle and calves are produced in all areas of Louisiana (Figure 60). According to 1974 Census of Agriculture data, Farming Areas 2, 4, and 7 had the largest number of cattle and calves, 17.6, 14.5, and 18.5 percent, respectively, of the total number of cattle and calves in Louisiana. In contrast, Farming Area 9 accounted for less than 1 percent of the cattle in the state.

Hogs and Pigs

The number of hogs and pigs in Louisiana peaked in 1944 at just over one million head, and then generally declined until 1965 (Figure 58). Hog and pig numbers have been relatively stable since 1965. Hog numbers averaged almost 904,000 between 1940 and 1944, compared with only 155,400 head for the years 1972 to 1976. In 1977 the number was up to 160,000 head.

Total production of hogs and pigs also declined until about 1961 (Figure 59). Production peaked for the period from 1940 to 1976 at 178.4 million pounds in 1943 and averaged 154.9 million pounds between 1940 and

Figure 56. Number of Cattle and Calves, Louisiana, 1940-1976.

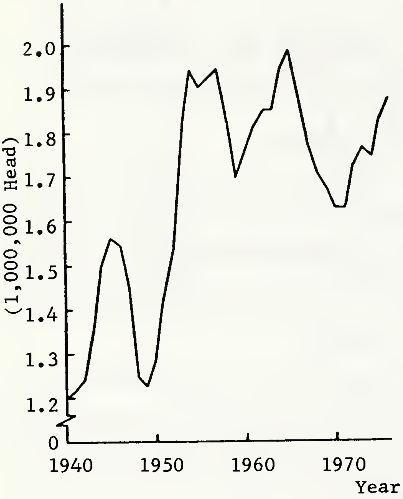


Figure 57. Total Production of Cattle and Calves, Louisiana, 1940-1976.

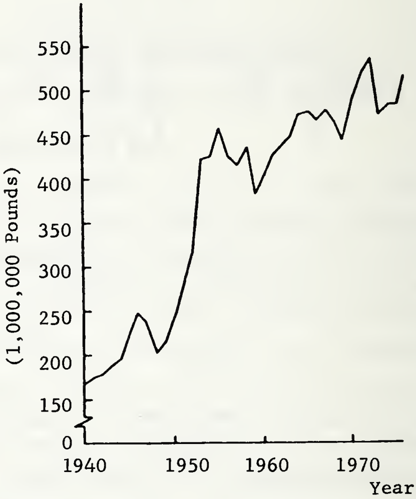


Figure 58. Number of Hogs and Pigs, Louisiana, 1940-1976.

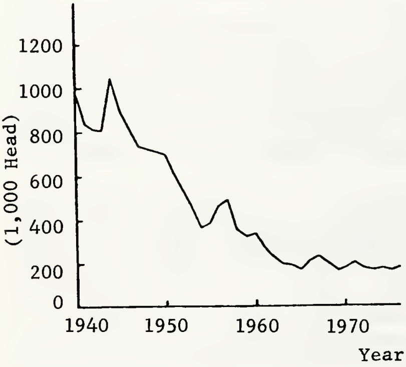
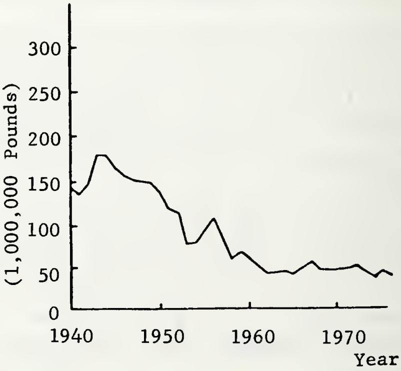


Figure 59. Total Production of Hogs and Pigs, Louisiana, 1940-1976.



1944. Production declined between 1943 and 1961, and was relatively stable after 1961, averaging 43.6 million pounds between 1972 and 1976. In 1977 production was 43.2 million pounds.

In 1974, Farming Area 4 accounted for almost 39 percent of the hogs and pigs in the state (Figure 61). Hog production is also relatively important in Areas 2, 3, 6, and 7.

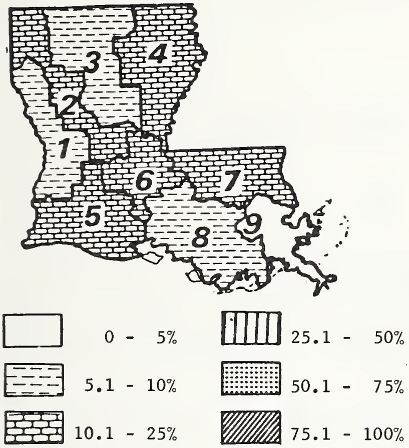


Figure 60. Concentration of Cattle and Calves, by Farming Area, Louisiana, 1974.

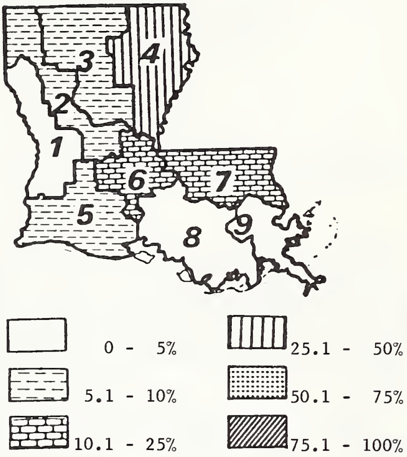


Figure 61. Concentration of Hogs and Pigs, by Farming Area, Louisiana, 1974.

Milk and Milk Cows

Some fluctuation occurred in the number of milk cows in Louisiana between 1940 and 1954 (Figure 62). The number of milk cows ranged between 283,000 and 310,000 head during that 15-year period and averaged 289,600 between 1940 and 1944. Since 1955, however, there has been a gradual but continuous decrease in the number of milk cows in the state. By 1975, the number had declined to 136,000. The average number of milk cows in Louisiana between 1972 and 1976 was 142,000, or about 50 percent of the number that existed at the beginning of the period under study. In 1977 the number of milk cows was 132,000 head.

While the number of milk cows declined, milk production per cow increased significantly (Figure 63). Production per cow averaged only 2,292 pounds during the years 1940 to 1944. Production per cow increased gradually until 1955 and then increased at a much faster rate. Milk production per cow averaged 7,610 pounds between 1972 and 1976 and reached a record level of 8,258 pounds per cow in 1976, an increase of 260 percent over the 1940 to 1944 average.

A significant part of the decline in the number of milk cows and the increase in milk production per cow can be explained by the decrease in the number of low-producing and/or non-commercial herds. In 1940, the amount of milk consumed on farms was greater than the quantity of milk sold by Louisiana farmers. This reflects the common practice of maintaining a milk cow on the farm to meet family consumption needs. As this practice declined, the number of milk cows declined and the remaining commercial herds had a higher level of milk production per cow.

The increase in milk production per cow has, in general, more than offset the decline in cow numbers, as production of milk in Louisiana generally increased during the period (Figure 64). Total production averaged 664.2 million pounds for the period from 1940 to 1944. For the period from 1972 to 1976, production averaged 1,079 million pounds, or 64 percent more

Figure 62. Number of Milk Cows, Louisiana, 1940-1976.

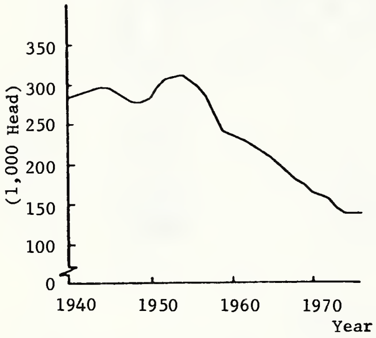


Figure 63. Production per Milk Cow, Louisiana, 1940-1976.

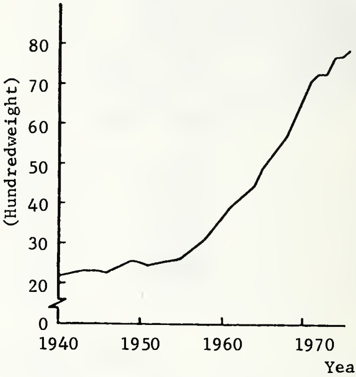


Figure 64. Total Production of Milk, Louisiana, 1940-1976.

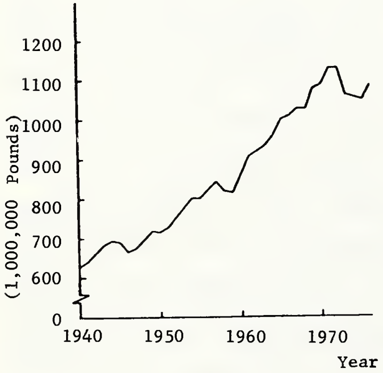
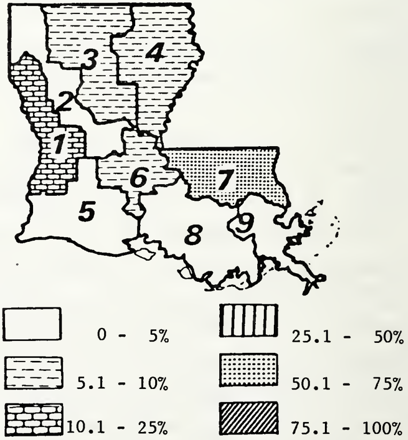


Figure 65. Concentration of Milk Cows, by Farming Area, Louisiana, 1974.



than in the earlier period. This increase in production was accomplished with about one-half as many cows. Total production declined between 1973 and 1975 but recovered somewhat in 1976. Production was 1,090 million pounds in 1977.

In 1974, over 50 percent of the milk cows in Louisiana were in Farming Area 7, which is near the New Orleans and Baton Rouge metropolitan areas (Figure 65). Farming Area 1 accounted for 12.7 percent of the dairy cows, with the remaining milk cows located throughout the other areas of Louisiana.

Laying Chickens and Eggs

The number of laying chickens in Louisiana has undergone two cycles since 1940 (Figure 66). The number of laying chickens peaked at more than 4.1 million in 1944, declined to less than 2.4 million in 1955 and then increased again to almost 3.9 million in 1969. After 1969, the number of laying chickens decreased to an average of 3 million for the period from 1972 to 1976. The number of laying chickens had decreased to 2.6 million in 1977.

The number of eggs per layer per year increased steadily between 1940 and 1976 (Figure 67). An average of 98 eggs per laying hen per year from 1940 to 1944 increased to 226 eggs per layer between 1972 and 1976. In 1976, the average was 237 eggs per layer, but it dropped to 227 eggs in 1977.

Total production of eggs in Louisiana increased dramatically between 1955 and 1976 because of the increase in number of eggs per layer (Figure 68). About 680 million eggs per year were produced in Louisiana between 1972 and 1976. Annual production averaged only 348 million eggs between 1940 and 1944. Egg production peaked for the period from 1940 to 1976 in 1969 when about 839 million eggs were produced in Louisiana. Over 598 million eggs were produced in 1977.

According to 1974 census data, laying chickens were concentrated in Farming Area 7 (Figure 69). Almost 60 percent of the layers were located in that area. Farming Areas 2 and 3 accounted for about 17 and 10 percent, respectively. Farming Area 1 accounted for about 5.5 percent, and all other Farming Areas had less than 5 percent of the layers in 1974.

Broilers

The period 1950-1976 was one of major expansion for the Louisiana broiler industry (Figure 70). An average of 1 million broilers raised in Louisiana during the 1940's increased steadily to an average of more than 54 million between 1972 and 1976. Over 63.6 million broilers were raised in Louisiana in 1977.

Total production of commercial broilers (in pounds) exhibited the same rapid growth pattern (Figure 71). An average of about 2.4 million pounds

Figure 66. Number of Laying Chickens, Louisiana, 1940-1976.

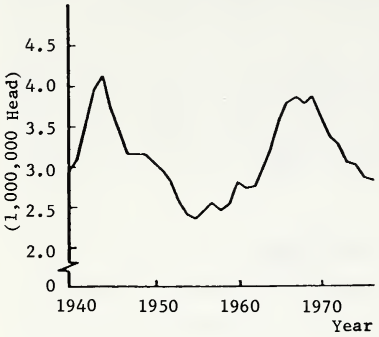


Figure 67. Number of Eggs per Layer, Louisiana, 1940-1976.

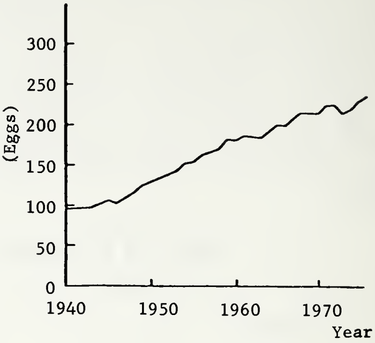


Figure 68. Total Production of Eggs, Louisiana, 1940-1976.

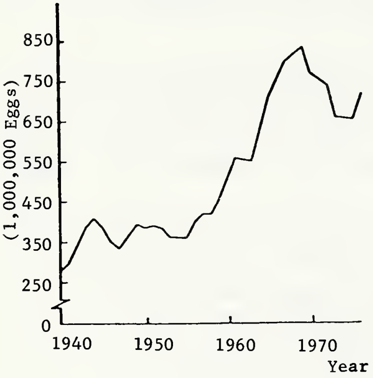
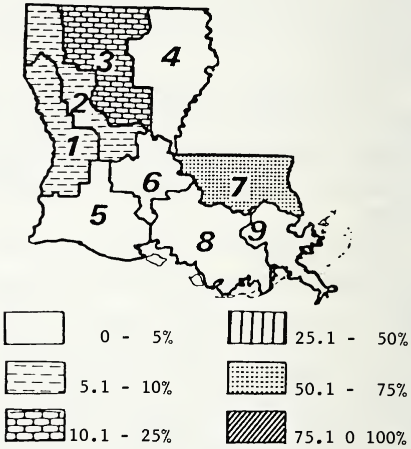


Figure 69. Concentration of Laying Chickens, by Farming Area, Louisiana, 1974.



per year were produced between 1940 and 1944, compared with 199.5 million pounds per year between 1972 and 1976. Almost 235.5 million pounds of broilers were produced in 1977, the largest production year in Louisiana history.

Farming Areas 1, 2, and 3 were the major broiler producing areas in 1974 (Figure 74). They produced about 29, 12, and 55 percent of the broilers, respectively. Other farming areas accounted for less than 5 percent of the broilers.

Sheep and Lambs

The number of sheep and lambs in Louisiana has declined considerably since 1940 (Figure 72). In 1942, there were 296,000 head of sheep and lambs on Louisiana farms, and the average for the period from 1940 to

Figure 70. Number of Commercial Broilers, Louisiana, 1940-1976.

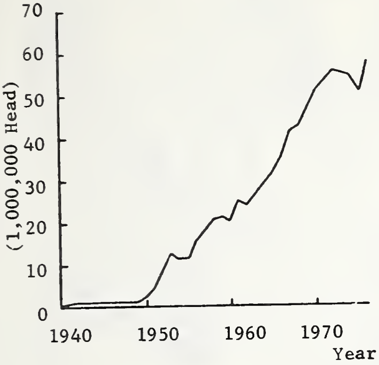


Figure 71. Total Production of Commercial Broilers, Louisiana 1940-1976.

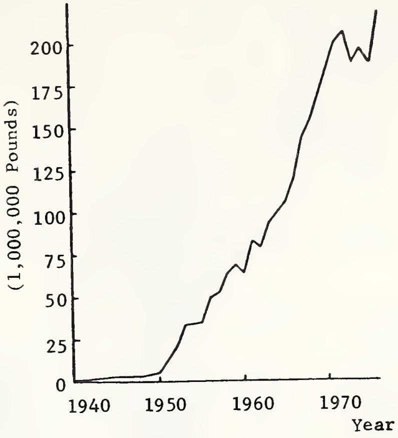


Figure 72. Number of Sheep and Lambs, Louisiana, 1940-1976.

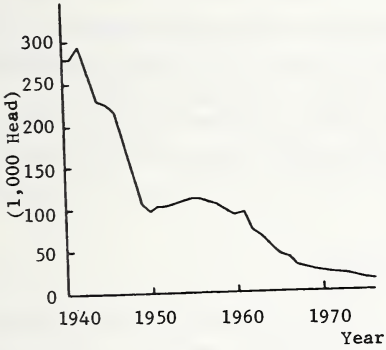
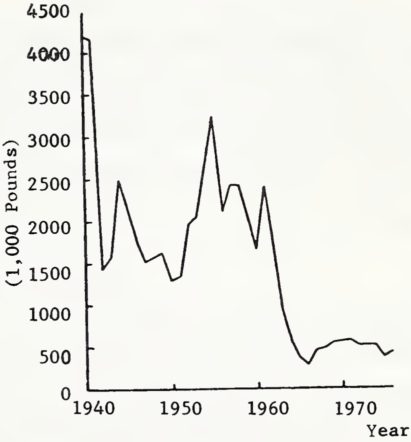


Figure 73. Total Production of Sheep and Lambs, Louisiana, 1940-1976.



1944 was 269,000 head. Sheep and lamb numbers fell below 50,000 for the first time in 1965, and the average for the period from 1972 to 1976 was only 17,600 head. By 1977 numbers had declined to 13,000 head. Sheep do not perform well in Louisiana because of the warm, humid climate. This factor is largely responsible for the decline in the number of sheep and lambs.

Total production of sheep and lambs also declined, especially during the period from 1955 through 1966 (Figure 73). A record high level of production for the period of 3.2 million pounds in 1955 was followed by a

Figure 74. Concentration of Broilers, by Farming Area, Louisiana, 1974.

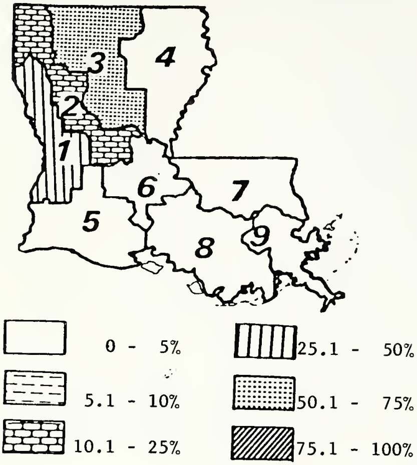
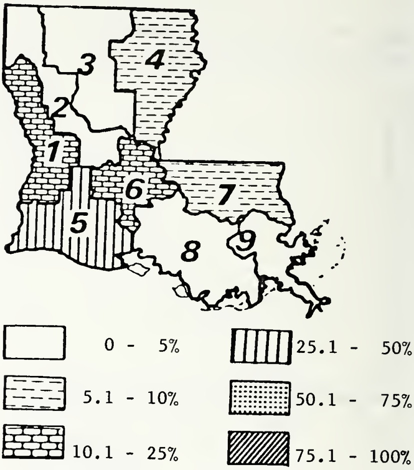


Figure 75. Concentration of Sheep and Lambs, by Farming Area, Louisiana, 1974.



record low for the 35-year period of only 280,000 pounds in 1966. Since that time, production has recovered slightly and averaged 458,800 pounds for the years 1972 to 1976. The increase in pounds produced since 1966 was achieved even though the number of sheep and lambs continued to decline during the period. Over 490,000 pounds were produced in 1977.

Slightly more than 40 percent of Louisiana sheep and lambs were in Farming Area 5 in 1974 (Figure 75). Areas 1 and 6 ranked second and third with 19.3 and 17.5 percent, respectively.

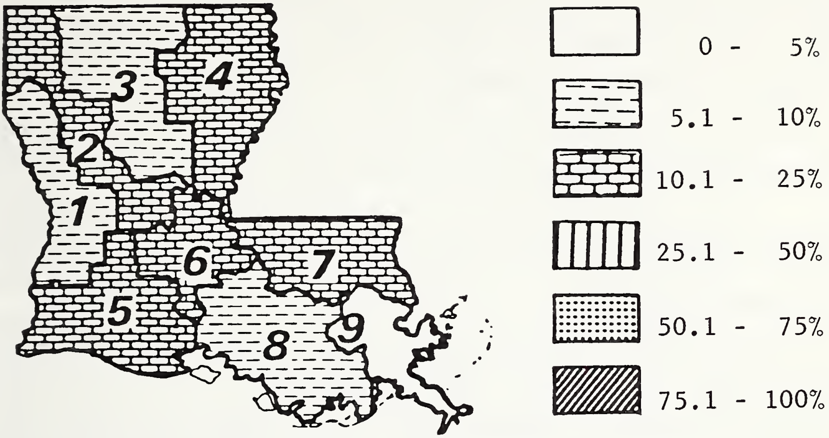
Horses and Mules

Between 1940 and 1974 the number of horses and mules in Louisiana declined from 317,000 to 15,000. Most of the horses and mules used as workstock in earlier years have been replaced by tractors. Most of the remaining horses are used primarily for pleasure riding and working cattle. A new facet of the horse industry is developing, however. A growing number of quarter horse and thoroughbred farms are producing race horses. Horse racing is a popular leisure activity in Louisiana, and an increasing number of race tracks are operating in Louisiana and neighboring states. The race horse industry will probably continue to grow in the future. Figure 76 shows the concentration of horses in each farming area for 1974.

VI. LOUISIANA'S FORESTS

Forestry, or timber production, is a specialized type of agriculture. Trees are planted and harvested like other agricultural crops, with the major difference being the time span between planting and harvesting. About 12

Figure 76. Concentration of Horses, by Farming Area, Louisiana, 1974.



years are required between the planting and harvesting of pulpwood, while a minimum of about 40 years is required for sawtimber. Louisiana forests are increasingly managed to improve yields and quality of the timber crop. Management and cultural practices have become more important in recent years as new seedling forests replace the virgin forests harvested in the past.

Forestry is an important part of the Louisiana economy. About 15 million acres, comprising 50 percent of the state's area, are forested, and over 14 million acres are classified as commercial forest. Both softwood and hardwood forests are found in Louisiana. Softwood forests comprise about 54 percent of the growing timber stock, and hardwood forests account for the other 46 percent. Pine is the most important softwood variety, accounting for about 87 percent of the softwood timber. Major hardwood varieties are oak and sweetgum. Together they make up about two-thirds of the hardwood growing stock. Other major commercial varieties of trees in Louisiana include red cedar, cypress, hickory, ash, cottonwood, willow, elm, and pecan.

Generally speaking, the softwood forests are located in the hilly upland regions of the state, particularly Farming Areas 1, 3 and 7. Hardwood forests are located in the delta areas of the major rivers and bottom lands along lakes and streams. The extreme southern part of the state bordering the Gulf has few if any commercial forests.

Land area in commercial forests decreased from 16 million acres in 1960 to 14.5 million in 1974. This represents a 9 percent decrease in commercial forest land in the state. Nevertheless, the volume of growing timber has steadily increased in Louisiana. For example, the growing stock of softwoods increased 31 percent between 1964 and 1974. This was only partially offset by a 7 percent decrease in the growing stock of hardwoods during the same period. Many acres of hardwood forests located near populated areas and major farming areas have been cleared to increase cropland and for urban and industrial development. This has caused a decrease in the hardwood growing stock in Louisiana.

Unlike many other areas of the U.S., the rate of timber growth in Louisiana is greater than the rate of timber harvested. For example, growing stock increased by 928.8 million cubic feet in 1974 compared to 601.4 million cubic feet harvested during the same year. This represents a net increase of 327 million cubic feet in 1974. If this favorable growth pattern continues, the wood product industries will be favorably endowed in the coming years.

Acreage of commercial forests in each farming area is presented in Table 11. Over 50 percent of the land in Farming Areas 1, 2, 3, and 7 is in commercial forests. About two-thirds of Louisiana's commercial forests are located in these four farming areas. On the other hand, forests occupy less than 20 percent of the total area in Farming Areas 5 and 9 in south Louisiana.

Only 7 percent of Louisiana forest land is publicly owned (Table 11). Public ownership includes forest lands owned by federal, state, parish, and municipal governments. The proportion of forest land in public ownership is higher in Farming Areas 2 and 3 because Kisatchie National Forest is located in those areas, extending also into Farming Area 1.

Forest industry firms own about 26 percent of Louisiana's forest land,

Table 11.—Area in commercial forests and forest ownership, by farming area, Louisiana, 1974

Farming Area	Commercial Forests		Commercial Forest Ownership			
	Acreage (1000 acres)	Percent of Total Area	Public	Forest Industry	Farms	Private
			Percent			
1	2216.9	77.3	5.5	34.4	8.3	50.8
2	1998.3	64.0	15.4	13.3	15.6	55.7
3	3425.4	82.4	10.2	35.3	14.3	40.2
4	1718.8	39.2	5.0	38.2	14.0	42.8
5	696.7	16.7	1.5	22.9	8.5	67.1
6	814.0	41.7	2.8	15.5	26.5	55.2
7	1950.1	59.4	2.3	24.3	19.8	53.6
8	1629.7	34.1	3.1	6.8	12.6	77.5
9	76.8	3.3	4.9	0	6.3	88.8
State*	14,526.0	46.8	7.0	25.9	14.5	53.1

*Farming Area totals may not sum to state totals due to rounding errors.

Source: Jacqueline M. Earls, *Forest Statistics for Louisiana Parishes,* Forest Service Resource Bulletin SO-52, Southern Forest Experiment Station, New Orleans, Louisiana, 1975.

with ownership concentrated in Farming Areas 1, 3, 4, and 7. Farmers own 14.5 percent of the commercial forest land while other private individuals and businesses own about 53 percent.

Louisiana's timber resources are utilized mainly for pulpwood, sawtimber, and related products. Data in Table 12 show the quantities of timber harvested by primary uses in 1974. More than 1,196 million board feet were harvested for sawtimber, and 3.7 million cords were harvested for pulpwood. Pine accounted for about 77.5 percent of the harvested sawtimber and 73 percent of the harvested pulpwood. Oak was the most important variety of hardwood sawtimber, accounting for about 10 percent of sawtimber harvested in 1974.

More timber was harvested for both sawtimber and pulpwood in Farming Area 3 in 1974 than any other area. Area 3 accounted for over 34 percent of the harvested sawtimber and 32 percent of the harvested pulpwood in 1974. Areas 1, 2, 3, and 7 combined accounted for 81 percent of the harvested sawtimber and 80 percent of the harvested pulpwood.

Income received by public and private landowners from the sale of timber in 1974 was about $110.6 million. Over $36 million in timber was harvested in Farming Area 3, and about $22 million from Farming Area 7. The value of harvested timber was in excess of 5 million dollars in all farming areas except Areas 6, 8, and 9.

The leading parish in terms of the value of harvested timber in 1974 was Winn Parish in Area 3. About $8.4 million of timber was harvested, and pine accounted for about 86 percent of the total. Winn Parish ranked first in volume of sawtimber harvested and eighth in pulpwood harvested.

Table 12.—Amount of sawtimber and pulpwood harvested and total stumpage value of harvested timber, by farming area, Louisiana, 1974

Farming Area	Timber Harvested		
	Sawtimber (1,000 bd. ft.)	Pulpwood (1,000 st. cords)	Total Value ($1,000)
1	180,022.8	823.7	$19,118.1
2	133,822.2	568.9	13,596.0
3	416,263.1	1,214.9	36,367.2
4	138,139.8	455.0	9,996.2
5	24,783.2	174.3	6,473.3
6	43,143.6	97.5	2,363.0
7	242,818.7	409.5	21,972.7
8	17,270.9	10.1	726.7
9	191.2	*	9.2
State Total**	1,196,455.5	3,753.9	$110,622.4

*Less than 500 cords.

**Farming area totals may not sum to state totals due to rounding.

Source: *Timber and Pulpwood Production in Louisiana: 1974*, Louisiana Forestry Commission, Baton Rouge, Louisiana.

Beauregard Parish in Area 1 was the leading parish for harvested pulpwood. Livingston Parish (Area 7) ranked second behind Winn Parish in terms of the value of harvested timber. Other parishes in which the value of harvested timber was more than $5 million in 1974 were Natchitoches, Sabine, and Union.

Forestry is an important part of agriculture in Louisiana today. In some parishes the value of harvested timber is greater than the value of all other agricultural products marketed. Forestry provides an excellent production alternative for areas not well suited for other agricultural production because of topography or soil characteristics and provides the basic resource needed to support the wood products industry in the state. The importance of the wood products industry and other agricultural business activities is discussed in Section VIII.

VII. AQUACULTURE[8]

Louisiana is the leading aquaculture state in the nation in acres devoted to production of aquatic food animals. Currently, close to 50,000 acres are devoted to crawfish farming alone, while there are only about 55,000 acres devoted to catfish farming in all the states combined. During the 1977-1978 season an estimated 40 million pounds of crawfish were harvested. Approximately 70 percent of the total was wild-caught from the Atchafalaya Basin, and 30 percent came from ponds. At a conservative price of 50 cents per pound, the value of the commercial catch came to $20 million. The recreational catch was estimated at 5.6 million pounds or $2.8 million, bringing the total value of the crawfish catch to $22.8 million. This figure represents only the dollar value at harvest. The crawfish industry produces far more revenue when one considers other segments such as processing, retailing, wire for traps, boats, motors, etc.

Expenses to grow crawfish in rice fields are relatively low. Major expenses include wire to build traps, bait, and labor for harvesting. Crawfish are not fed, and fields are not refertilized. Crawfish feed on decaying rice hay and on micro-organisms

The acreage increase in crawfish farming has been dramatic, from only 6,000 acres in 1966, to 18,000 acres in 1970, to 45,000 in 1976, to close to 50,000 in 1978.

A major trend is underway in crawfish farming—double cropping rice and crawfish. Until 1975 some rice farmers grew crawfish in rice fields on a hit-or-miss basis. Crawfish, in some cases, were not stocked but came in naturally. If rain fell at the right time (in the fall of the year), the rice farmer frequently had a crop of crawfish. Rice farmers were reluctant to grow crawfish seriously for a variety of reasons. Bait for trapping had to be purchased and stored in a freezer. Labor for harvesting was not always available. And there was no serious research to answer the farmer's many problems, such as the effect of rice pesticides on crawfish.

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[8] Material obtained from Dr. James Avault, Professor, School of Forestry and Wildlife Management, LSU Agricultural Experiment Station, Baton Rouge.

In spite of these problems, the number of rice farmers double cropping rice and crawfish has increased. During the 3 years from 1975 to 1977, when prices were low for rice, prices were high for crawfish. Farmers often received 90 cents a pound live weight for crawfish at the begnning of the season. Later in the season they received 60 cents, and toward the end of the season 35 to 45 cents. With good management rice farmers can produce 1,000 pounds of crawfish per acre. Assuming an average price of 60 cents, gross returns are $600 per acre.

Table 13.—Status of freshwater aquaculture in Louisiana, 1976

	Commodity			
Farm Input	Crawfish	Catfish	Minnows	Crickets & Worms
No. farms	334	105	35	50
Acreage	45,000	6,500	—	—
No. employed on farm	1,002	210	70	150
No. involved in processing	300	50	70	150
Jobbers	30	10	10	10
Retail business	500	100	300	300

Source: LSU Cooperative Extension Service.

The state's second largest aquaculture acreage is devoted to catfish (see Table 13). The culture of small pet turtles and of minnows, crickets, and worms for fishing bait represents a substantial portion of the aquaculture income in Louisiana, and alligator farming is rapidly becoming important. Another growing segment of the aquaculture economy is the oyster industry; in 1978 some 88,000 acres of public water bottoms were privately leased for oyster culture.

VIII. LOUISIANA'S AGRIBUSINESS SECTOR

The preceding sections of this bulletin describe the size and importance of the farm and timber production sectors in the Louisiana economy. Production data, however, only partially account for the total economic activity associated with agriculture and forestry. Marketing and other agricultural services are also important aspects. As farms increase in size, they often become more specialized. Farmers now purchase many of the basic inputs and services needed to produce and market their products. The movement away from self-sufficiency on the farm and toward more specialization in production has created a need for new types of agriculturally oriented business firms. These farm-supporting business firms are usually referred to as the ''agribusiness sector'' of the economy.

Generally speaking, agribusiness firms perform one of three basic functions. First, they provide the inputs or materials needed to produce farm products. For example, agribusiness firms provide seed, fuels and lubricants, machinery, feed, fertilizer, herbicides, insecticides, tires, building materials, and other products used on farms. Second, firms provide specialized services to farmers, such as financing, crop and livestock insurance, aerial application of chemicals and fertilizers, insect scouting, and contract harvesting of crops. And third, agribusiness firms are involved with advertising, processing, transporting, storing, packaging, and merchandising farm products. Thus, the agribusiness sector includes all firms involved in the manufacture and distribution of farm supplies, the production, assembly, storing, processing, and distribution of farm products and items manufactured from them.

Perhaps the scope of the agribusiness sector can be best illustrated with an example. Dairy farmers require many products and services to produce milk. They need feed, seed, herbicides, veterinary supplies and services, milking equipment and facilities, legal and accounting services, fencing supplies, and other goods and services. Many of these supplies, materials, and services are purchased from local agribusiness firms. Once produced, the milk is transported to processing plants for pasteurization or the manufacture of other dairy products such as cheese and butter. Milk plants also require supplies and services of all kinds, including legal, accounting, and advertising services. After processing, milk products are then transported to grocery stores and other outlets for final distribution to consumers. The milk processing plants, transportation firms, and even grocery stores are part of the agribusiness complex. Production, processing, and distribution of other agricultural products are equally dependent on the agribusiness sector. Hence, the agribusiness sector includes much more than the farm firms that produce the basic agricultural commodities. Figure 77 illustrates some of the products and services provided by agribusiness firms and their basic relationship to the farm firm.

The agribusiness sector is of prime importance to the economy of the United States. It has been estimated that agribusiness accounts for about 20 percent of America's gross national product (GNP—a measure of the total market value of all final goods and services produced in the economy in a given year).[9] In other words, about one-fifth of the total economic activity in the U.S. is conducted by firms in the agribusiness sector of the economy. This clearly indicates the size, scope, and importance of agriculture-related business in the United States.

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[9] Schluter, Gerald E., ''Food and Fiber Sector Generates Nearly a Fourth of All Business Activity,'' *The Farm Index,* U.S. Department of Agriculture, Washington, D.C., May 1974.

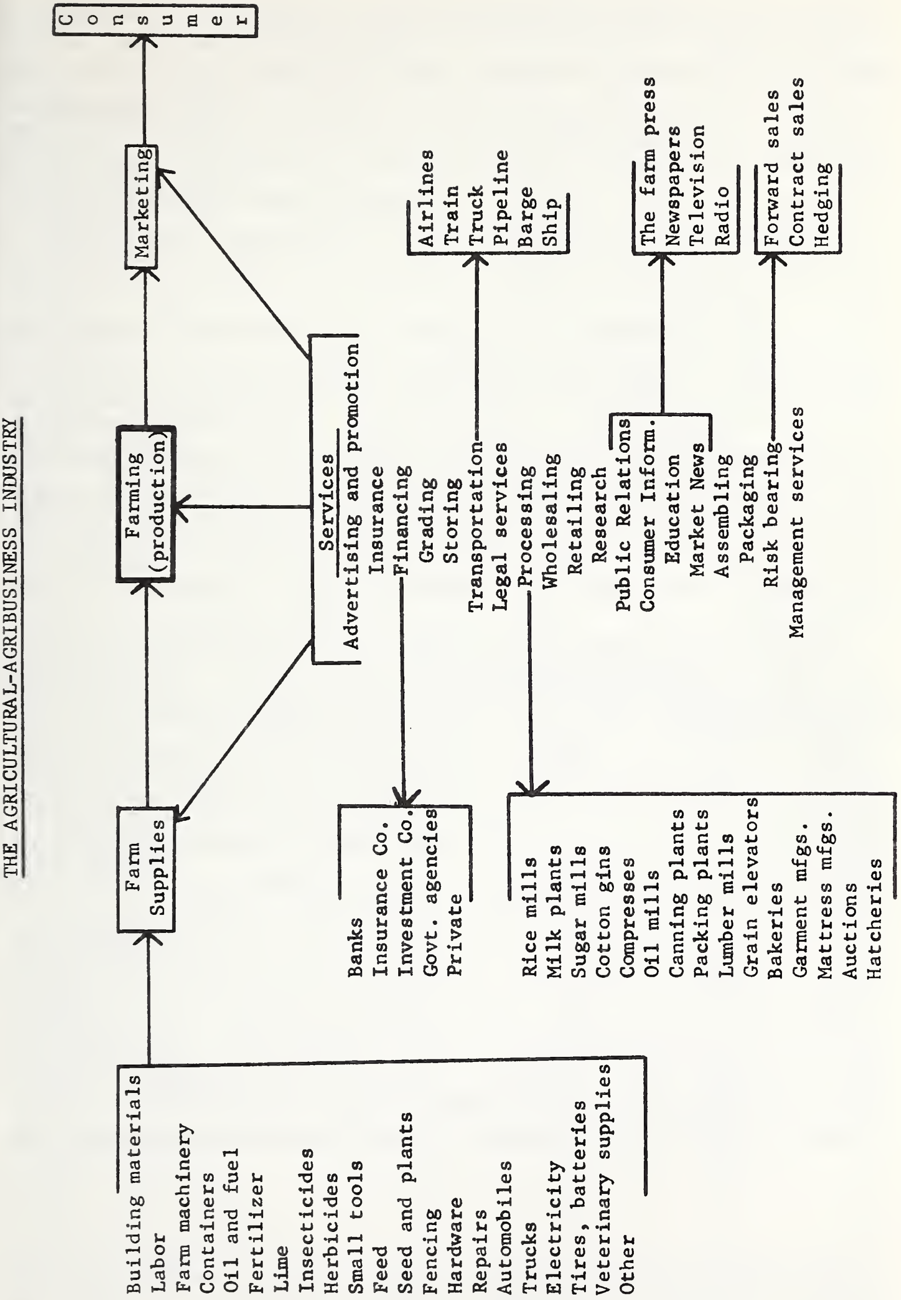

Figure 77.—The agricultural-agribusiness industry. (Source: Fred H. Wiegmann, "Farming and Agribusiness in the Louisiana Economy," *Louisiana Economist*, Vol. 33, No. 2, May 1971.)

Data are not readily available to present a complete analysis of the size and importance of the agribusiness sector in Louisiana. However, some pertinent information is available from U.S. census reports. The reader should note that the firms and industries discussed below are associated with agriculture in general and not just Louisiana agriculture. For example, food stores sell products not all of which are produced or processed in Louisiana, and sugar refineries in Louisiana process imported as well as Louisiana sugar. However, the firms and industries are closely related to agriculture and forestry and are considered part of the agribusiness complex in the state.[10]

Data from the *Census of Manufactures* indicate that over 1,700 agriculture-related manufacturing firms conducted business in the state in 1972 (Table 14). This represented about 47 percent of all manufacturing firms in Louisiana. There were more firms in the Lumber and Wood Products and the Food and Kindred Products industries than in any other manufacturing industry in the state in 1972. Furthermore, the two industries accounted for almost 38 percent of all manufacturing firms that employed 20 or more workers. This shows that agribusiness manufacturing firms are not only numerous in Louisiana—many of them are also relatively large.

The Food and Kindred Products industry was also the largest employer among all manufacturing industries in Louisiana in 1972, employing more than 28,000 people (Table 15). The lumber and paper industries were also major employers, providing jobs for 14,700 and 15,500 people, respectively. In total, the agribusiness manufacturing firms provided jobs for more than 70,000 people, or about 39 percent of all people employed in manufacturing during the census year. The chemical industry and the transportation equipment industry are also important industries. Each employed more than 20,000 people in Louisiana in 1972.

In terms of 1972 annual payroll and total sales, the Food and Kindred Products industry ranked third in the state, and the Paper and Allied Products industry was fourth. The Lumber and Wood Products industry ranked sixth in payroll and sales. In all, the agribusiness manufacturing firms accounted for 31.5 percent of the manufacturing payroll and 31 percent of the total sales of all manufacturing firms in 1972.

Data in Tables 14 and 15 indicate that agribusiness manufacturing firms are more labor intensive than other manufacturing industries. That is, the agribusiness industries apparently require more labor per dollar of output. For example, one worker produced an average of about $50,000 of output in the agribusiness manufacturing categories, compared to an average of $71,200 of output per worker produced in other manufacturing categories. Agribusiness manufacturing is important in providing employment opportunities in the Louisiana economy.

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[10] For a description of that part of the agribusiness sector that is more directly associated with agricultural production in Louisiana, see: S.D. Reiling and L. J. Guedry, "The Economic Importance of Agriculture in Louisiana," *Louisiana Agriculture,* Louisiana Agricultural Experiment Station, Vol. 20, No. 4, 1977 and Fred H. Wiegmann, "Farming and Agribusiness in the Louisiana Economy," *Louisiana Rural Economist,* Vol. 33, No. 2, May, 1971.

Agribusiness firms are also found in the wholesale, retail, and service sectors of the economy. Census data for these sectors are summarized in Table 16. Agribusiness firms in the wholesale sector numbered 1,649 in 1972 and employed over 27,200 workers. Wholesale grocery establishments were the most numerous and employed the most workers. In all, agribusiness wholesale firms paid $129 million in wages and recorded sales of $3.2 billion in 1972.

An additional 7,000 agribusiness firms were included in the retail and service sectors. They employed about 33,800 workers and paid almost $158 million in wages in 1972. In total, these firms had more than $5.2

Table 14.—Number of agribusiness and other manufacturing establishments, Louisiana, 1972*

	Establishments			
			With 20 or More Employees	
Major Industry Group	Number	Percent of Total	Number	Percent of Total
Agribusiness Manfacturing				
Food and Kindred Products	566	15.5	285	25.1
Textile Mill Products	12	0.3	7	0.6
Apparel and Related Products	91	2.5	57	5.0
Lumber and Wood Products	930	25.4	142	12.5
Furniture and Fixtures	65	1.8	15	1.3
Paper and Allied Products	62	1.7	52	4.6
Sub-total	1,726	47.2	558	49.1
Other Manufacturing				
Printing and Publishing	467	12.8	70	6.2
Chemicals and Allied Products	212	5.8	98	8.6
Petroleum and Coal Products	58	1.6	33	2.9
Stone, Clay and Glass Products	221	6.0	73	6.4
Primary Metal Industries	28	0.8	19	1.7
Fabricated Metal Products	201	5.5	72	6.3
Machinery, except electrical	293	8.0	71	6.3
Electric and Electronic Equipment	45	1.2	15	1.3
Transportation Equipment	171	4.7	73	6.4
Misc. Manufacturing Industries	236	6.4	53	4.8
Sub-total	1,932	53.0	577	50.9
Total, all firms	3,658	100.0	1,135	100.0

*Excludes farms, a vital segment of agribusiness.

Source: Compiled from *Census of Manufactures:* 1972, Area Series, Louisiana, MC 72 (3)-19, 1975.

billion of sales in 1972. Food stores were the largest category of agribusiness retail establishments. They accounted for about 92 percent of the firms and 86 percent of the employees in 1972.

In conclusion, *the importance of agriculture in Louisiana's economy extends far beyond the farm gate.* There were more than 10,000 agribusiness firms in the manufacturing, wholesale, retail, and service sectors, employing 130,000 workers in 1972. The annual payroll of these firms in the same year was over $794 million, and total sales were in excess of $8.7 billion.

It should be noted that these data do not completely account for all the agribusiness industry in Louisiana. The census data are not well suited for distinguishing agribusiness firms from other types of firms. Furthermore, some large agribusiness complexes are not listed in the census reports. For example, Louisiana has several deep water ports. It has been estimated that more than 30 percent of the total U.S. agricultural exports in 1974, valued

Table 15.—Employment, payroll, and total sales of agribusiness manufacturing and other manufacturing establishments, Louisiana, 1972*

Major Industry Group	Employment		Payroll		Total Sales	
	Number (1,000)	Percent of Total	Million Dollars	Percent of Total	Million Dollars	Percent of Total
Agribusiness Manufacturing						
Food and Kindred Products	28.1	15.6	$197.0	12.3	$1,936.1	17.0
Textile Mill Products	1.3	0.7	7.0	0.4	44.9	0.4
Apparel and Related Products	9.0	5.0	43.8	2.7	132.5	1.2
Lumber and Wood Products	14.7	8.2	90.0	5.6	474.4	4.2
Furniture and Fixtures	1.5	0.8	7.6	0.4	29.5	0.3
Paper and Allied Products	15.5	8.6	161.9	10.1	879.3	7.8
Sub-total	70.1	38.9	$507.3	31.5	$3,496.7	31.0
Other Manufacturing						
Printing and Publishing	7.4	4.1	55.8	3.5	182.4	1.6
Chemicals and Allied Products	24.4	13.6	303.5	18.9	2,604.4	23.1
Petroleum and Coal Products	9.5	5.3	121.9	7.6	2,917.9	25.8
Stone, Clay and Glass Products	6.7	3.7	54.4	3.4	267.1	2.4
Primary Metal Industry	7.3	4.1	75.1	4.7	329.9	2.9
Fabricated Metal Products	12.5	7.0	112.0	7.0	415.3	3.7
Machinery, except electrical	7.0	3.9	59.8	3.7	201.9	1.8
Electric and Electronic Equipment	7.0	3.9	59.1	3.7	301.5	2.7
Transportation Equipment	21.9	12.2	204.7	12.8	487.2	4.3
Misc. Manufacturing	5.8	3.2	48.7	3.0	86.3	0.7
Sub-total	109.5	61.0	1,095.0	68.3	7,790.9	69.0
Total all Manufacturing**	179.6	99.9	$1,602.3	99.5	$11,290.2	100.0

*Excludes farms, a vital segment of agribusiness.

**Data for individual categories do not sum to totals because of rounding error and data withheld from census reports to avoid disclosure of information for individual firms.

Source: *Census of Manufactures:* 1972, Area Series, Louisiana MC 72 (3)-19, 1975.

Table 16.—Number of firms, and employees, payroll, and value of sales for agribusiness firms in the wholesale, retail, and service sectors of the Louisiana economy, 1972*

Sector	Number of Firms	Number of Employees	Payroll ($1,000)	Value of Sales ($1,000)
Wholesale Sector[1]				
Lumber, Plywood & Millwork	154	2,613	$19,856	$250,224
Farm & Garden Machinery & Equip.	216	2,035	13,934	142,369
Groceries & Related Products	802	18,041	75,647	1,859,807
Farm Product Raw Materials	145	1,563	6,907	754,400
Farm Supplies	332	3,022	12,846	201,105
Sub-total	1,649	27,274	$129,190	$3,207,905
Retail[2] *and Service*[3] *Sectors*				
Nurseries, Lawn & Garden Supply Stores	84	215	989	6,805
Lumber & Other Building Material Dealers	457	4,518	25,811	208,552
Food Stores	6,500	28,928	130,276	1,819,912
Farm Machinery & Equip. Repair	28	133	915	3,711
Sub-total	7,069	33,794	$157,991	$2,038,980
Total	8,718	61,068	$287,181	$5,246,885

[1] *Census of Wholesale Trade:* 1972, Area Series, Louisiana, WC 72-A-19, 1975.

[2] *Census of Retail Trade*, 1972, Area Series, Louisiana, RC 72-A-19, 1975.

[3] *Census of Selected Service Industries:* 1972, Area Series, Louisiana, SC 72-A-19, 1974.

*Excludes farms, a vital segment of agribusiness.

at $6.9 billion, were shipped through Louisiana ports. Shipping and handling of agricultural exports through Louisiana ports is an important source of employment and income in the state even though data are not available in the census reports.

Other examples of agribusiness firms not included in the data presented above are cotton gins, agricultural financial institutions, aerial applicators, veterinary firms, and oil and fuel distributors. Although the data presented above do not provide a complete analysis of the agribusiness sector in Louisiana, they do indicate the broad scope of its activities. The complexity and the economic importance of agriculture and the vast agribusiness complex that serves the farm production sector and the consumer are often overlooked.

IX. TECHNOLOGICAL AND SOCIAL CHANGE IN RURAL AREAS

Agriculture has undergone significant changes in the last 35 years. Most notable has been the adoption of new technology and the application of improved production practices. Adoption of new technology has been one of the major factors behind the trend toward larger, more efficient farms in Louisiana and the United States, and thus toward lower food and fiber costs than would have otherwise been possible. Adoption of new technology often involves considerable capital investment in new machines and equipment. For the adoption to be profitable, it is often necessary to expand the size of the farm so that the associated fixed costs can be spread over more acres, thus reducing the cost per acre and cost per unit of output.

Farmers adopt new technology because they believe the economic gains associated with adoption will more than offset the additional costs. Technological change ordinarily results in lower per unit costs of production. Assuming market prices do not change over a short period of time, the technological change may increase ''short run'' profits of those farmers who adopt the technology early. This extra profit is usually only temporary, however. As more and more farmers adopt the technology, the volume of production of the industry will increase, the price of the product will fall, and the extra profit will disappear. Thus, the long run effect of technological change eventually results in lower prices for consumers of farm products. Agricultural technological research by the land grant colleges, government agencies, and others ultimately benefits consumers as much or more than it benefits farmers.

Benefits associated with agricultural technological advances are generally recognized and acknowledged. There are, however, some costs. Because of the interdependent nature of the economy and society, a change in a single sector or institution often induces or contributes to changes in other sectors. In the agricultural sector, improved technology has resulted in fewer, larger, and more mechanized farms. But fewer farms mean fewer farmers, and increased mechanization leads to fewer farm workers, both of which contribute to an erosion of the employment base of rural communities and out-migration of people from rural areas.

However, social and economic problems of rural areas are not solely related to technological changes in agriculture. Advances in education, transportation, and communication networks and a myriad of other factors have also had a considerable influence. The economic and employment base has been affected, and many rural areas have lost some of the vitality associated with large rural populations of the past. Many small rural towns lost their means of sustenance as people left rural areas, and those remaining shifted their purchasing power to larger communities, aided by better transportation and communication. However, some rural towns have also grown and prospered as a result of concentration and consolidation of rural businesses and services.

Recognition of the special problems of rural communities has led to special government programs to counter these problems. These programs are generally referred to as "rural development programs" and are designed to provide farm and nonfarm employment, income opportunities, and more attractive living conditions in nonmetropolitan areas of the nation. In other words, the programs are designed to help the rural social and economic systems adjust to new farm technology and other changes.

Rural development was initiated in 1955 when Congress first funded the Rural Development Program to stimulate economic development in rural areas with high unemployment or underemployment levels. Since that time, the programs have been expanded in size and scope. The U.S. Department of Agriculture has administrative responsibility for the programs because it possesses the infrastructure required to carry them out.

In Louisiana, as in other states, the Cooperative Extension Service has a leadership role in rural development. Other USDA agencies, such as the Farmers Home Administration and the Soil Conservation Service, are also actively involved. A Rural Development Committee has been established at the state level as well as in each parish. Committee membership includes USDA agency personnel, state and local organizations, and individuals interested in improving the economic and social well being of rural areas.

Rural development programs in the state have demonstrated some successes. For example, both Morehouse and LaSalle Parishes have received national awards for their development activities. Other parishes have also made progress; industries that provide new employment opportunities have been attracted to rural areas, water and sewer systems have been constructed to serve small rural communities, and farmers' markets have been established to help small farmers sell their vegetables and other products. Recreational facilities have been constructed, and drainage systems have been improved. Educational, medical, and transportation services have been upgraded, as have solid waste disposal systems. All of these programs have improved the quality of life in rural communities.

X. SUMMARY

Louisiana's agricultural industry has changed considerably since 1940. Specialization has occurred in crop and livestock enterprises in every area of the state. This specialization has been responsive to environment and changes in physical and economic forces. For example, areas with relatively infertile soil have reverted to forest and livestock production. Crop production, on the other hand, has become more concentrated in areas with more fertile soil. Areas with characteristics required for particular crops continue to specialize in those products.

Farms have become larger in recent years to take advantage of new technology and economies of size. Although the number of farms has declined, this simply reflects the general trend toward larger farms and increased efficiency, and changes in the definition of a farm. Fewer farms do not indicate that agriculture is a declining industry. To the contrary, acreage in crops has increased, as has investment in facilities, machinery, equipment, and operating supplies. The value of output has increased dramatically, reflecting increased physical production of many commodities, particularly soybeans. The combination of agriculture and agribusiness is a growing industry of prime importance to the economy of the state.

Agriculture's increases in yields reflect adoption of new biological and mechanical innovations to remain competitive. Livestock production has become more efficient. Mechanical harvesting is universal for almost all crops, with the exception of fruits, nuts, vegetables, and strawberries. Labor requirements have declined as a result of mechanization, and costs of production have also been moderated by new technology, resulting in benefits for the consumer.

The most notable change in crop trends has been the dramatic growth of soybean production in Louisiana. Soybeans, an insignificant crop in the 1940's and 1950's, became the most important crop in terms of acreage harvested and value of production in 1976. Traditional crops such as rice, cotton, and sugarcane continue to be important enterprises.

Livestock enterprises, especially the production of eggs and broilers, have experienced some growth. Although the number of milk cows has declined, production has increased because of a large increase in milk production per cow. Cattle numbers and production have been cyclical but generally have increased in importance, with production more than doubling since 1940.

Some commodities have experienced a downward trend since 1940. Most notable among these are corn, strawberries, vegetables, peaches, sweet potatoes, Irish potatoes, swine, and sheep. Changing market conditions and labor intensive production requirements for many of these commodities have contributed to their decline.

Forestry is an important facet of agriculture and occupies about half the land area in Louisiana. Softwood forests, especially pine, are dominant, but hardwood forests are also important as they provide both sawtimber and pulpwood for Louisiana-based industries.

Farm and forest production generate a large part of the economic activity of agriculture. They also give rise to a large agribusiness sector associated with agriculture and forestry. For example, manufacturing firms that process farm and forest products accounted for 47 percent of all manufacturing firms in Louisiana in 1972. They also provided 31 percent of the total employment in the manufacturing sector. Wholesale, retail, and service firms, related in some way to agriculture, employed more than 60,000 workers and paid $287 million in wages in 1972. Generally speaking, the agriculture-agribusiness sector and the oil and gas industry provide the major economic base for the economy of the state.

The outlook for Louisiana agriculture is promising. Good, productive farmland is a major renewable resource. A continuing increase in world population in the foreseeable future means a continuing and increasing demand for the products of our land resource.

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An Assessment of Housing of Indian, White, and Black Residents in Two Rural Louisiana Communities

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An Assessment of Housing of Indian, White, and Black Residents in Two Rural Louisiana Communities

FORREST A. DESERAN, ROBERT MULLEN, AND GARY STOKLEY*

Introduction

Considerable research has recently centered around problems of defining, measuring, and assessing quality of life (e.g. Andrews and Withey, 1976; Campbell *et al.*, 1976). Despite the inherent difficulties in conceptualization and measurement of such an elusive concept, there is general agreement that housing is of central importance to the concerns of most people. Because one's private dwelling is to a large degree the primary arena of everyday life, attempts to deal with the state of people's well-being should include consideration of housing situations.

Although most housing research has focused on urban areas, it has been estimated that in 1976 there were about 2 million rural families living in substandard housing in the United States (Bird and Kampe, 1977). Although this is a large number (about 10 percent of rural families), this figure is much lower than in 1950 when approximately 59 percent of rural families lived in substandard housing. Despite indications that housing conditions in non-metropolitan areas are continuing to improve (Bird and Kampe, 1977), the fact remains that a significant segment of our rural population continues to live in poor housing.

But research on the quality of rural housing and the effects of housing circumstances upon rural residents remains scarce. Housing policy has traditionally been based upon objective indicators of housing quality (i.e., plumbing, state of repair, rent outlay, crowding, etc.). And as such, housing programs have focused on improving physical aspects of housing with the assumption that attendent social problems would be improved. However, as a number of social scientists have indicated, improvements of physical aspects of housing have not necessarily resulted in noticeably improved living circumstances for residents (Rent, 1975). This suggests that housing research needs to include, in addition to objective indicators of housing quality, other potentially related factors (Zey-Ferrell *et al.*, 1977).

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The experiences of different groups of people (as defined by age, race, income, etc.) with housing have been examined in various studies. One common finding has been that racial identity tends to be related both to objective conditions and to subjective evaluations of housing (Rent, 1975; Andrews and Withey, 1976; Campbell *et al.*, 1976; Bird and Kampe, 1977). Nonwhite and lower income groups generally are less satisfied than white and upper income groups with their housing conditions. In addition, Bird and Kampe (1977) report that blacks and the aged are occupying increasing proportions of substandard rural housing although they represent a smaller share of the total rural population.

The general objective of this study is to take a close look at housing in two southern Louisiana communities which reflect some of the problems of specific groups noted in rural housing research. The unique racial mix of these two communities offers an ideal setting to examine intensively objective and subjective aspects of rural housing across racial lines. Despite the existing data which suggest non-white residents tend to fare less favorably than white residents in housing, no extensive research has attempted to compare Indian, black, and white housing within the same geographical area. Such a comparative examination is important if inferences are to be made concerning the effects of racial identity, as opposed to geographical setting or other related factors, upon housing.

Pursuant to attaining the general objective of this study, several specific objectives can be identified:

1. To compare objective aspects of housing. This includes the overall physical condition of housing, types of structures, levels of crowding, and ownership of household items.
2. To assess the relationships between characteristics of residents (income, employment status, age, education, and family size) and objective housing conditions.
3. To assess the relationship between subjective reactions to housing conditions (satisfaction with private dwelling and willingness to move to other dwellings) and resident characteristics (family size, income, age, and education).
4. To explore the relationship between objective conditions of housing and resident satisfaction with housing.
5. To analyze resident orientations toward housing in terms of general observations and insights gained from non-structured interviews and observations.

Before reporting the methods employed and the findings of this study, it is important to provide some background on the communities selected. As mentioned, selection of these communities was based upon their unique racial characteristics.

The Setting: Dulac and Grand Caillou

The Dulac and Grand Caillou communities are in an area referred to by Bertrand (1955:29) as "one of the largest cultural islands in rural Louisiana." Geographically, these communities are located in Terrebonne Parish, the largest parish in Louisiana, and situated on low-lying flatlands surrounded by bayous and salt marshes. The physical appearance of the communities varies little in comparison with other fishing oriented communities in the Gulf area. Inhabitants have settled in a line village fashion with dwellings located along each of the roads running parallel with Bayou Grand Caillou and Bayou Dulac for approximately 8 miles.

The racial composition of these communities is of particular importance. The population is predominantly composed of members of the Houma Indian tribe.[1] Although Louisiana has had many Indian tribes in its history, only five remain identifiable today of which the Houma are the largest. The Indians in the Dulac/Grand Caillou area are the largest of eight subcommunities of Houma in Louisiana. The cultural background of these Indians has been diluted and changed primarily under the influence of the French. The result is that there are few if any remnants of their language or culture, and "Cajun French" cultural characteristics predominate (Parenton and Pellegrin, 1950).

The history of this particular racial group can be traced back to the end of the 18th century when the Houma tribe and remnants of two other tribes settled in the vicinity (Stanton, 1971; Roy, 1959). By the first decades of the 19th century, white settlers with their slaves settled in Terrebonne Parish. Because the white settlers, who were primarily French, desired to farm the land, descendants of the tribes were pushed farther back into the major bayous leading to the Gulf of Mexico. The Indians offered little resistance, apparently because of their lack of interest in farming. From the intermixture of whites, blacks, and Indians through the years there has evolved a group called "Sabine," a term applied primarily to Indians having a tri-racial heritage (Parenton and Pellegrin, 1950; Roy, 1959).[2] At present there are various estimates as to the number of Indians in Terrebonne and adjacent LaFourche Parish, although the number appears to be about 1,800 for the area studied (Table 1).

According to all available documented information, the Indian popula-

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[1] The tribal origins of the Indians located in Terrebonne Parish is not clear cut, but there is sufficient evidence that the predominant Indian predecessors were Houma. See Parenton and Pellegrin (1950) for a detailed account of the historical background of this group.

[2] Our observations suggest that the term "Sabine" is not currently used by the Indians to refer to themselves and is considered by many to be a derogatory referent. See Roy (1959) for further substantiation of this observation.

Table 1.—Terrebonne Parish population figures[1] by ward,[2] 1977

Ward	White	Black	Indian	Total
1	10,456	1,748	0	12,240
2	966	322	0	1,288
3	37,020	7,100	303	44,423
4	2,866	481	1,791	5,138
5	3,271	42	6	3,313
6	2,549	166	571	3,286
7	6,203	734	118	7,055
8	1,785	1,285	8	3,078
9	2,488	195	28	2,711
10	2,326	767	191	3,284

[1] Census developed by the Management and Development Service for the Terrebonne Parish Police Jury, 1977.

[2] Grand Caillou/Bobtown and Dulac are in Ward 4, but do not compose the entire ward.

tion has been a loosely structured group lacking political organization. It has recently become more tightly-knit and organized because of issues involving better schools, improved roads, land ownership, and civil rights (Fischer, 1968; Stanton, 1971; Roy and Leary, 1977). Missionaries and clergy from the Catholic and Protestant faiths have rendered aid and assistance to the Houma from the early 1900's until today.

The majority of the Indians live in the Dulac area at the southern end of the community on the west side of Bayou Grand Caillou. A bridge connects the eastern side of Bayou Caillou to Bayou Dulac and another settlement which is predominantly Indian. This area is known as Lower Dulac. Most Indian males earn their living through fishing, trapping, or some other coast-related activity.

The majority of white residents live on the east side of Bayou Grand Caillou. This settlement represents the largest population cluster in the area and contains a majority of the business establishments and local services. The white residents in general own and operate the various businesses in the area and work in coast-related industrial jobs (oil fields, industrial labor, tug boat operations, etc.).

Black residents represent the smallest subpopulation in this area. Most of the black residences are clustered in the northern part of Grand Caillou in an area known locally as Bobtown. This area is surrounded by large cane fields and is probably a vestigal remnant of the former plantation system (Stanton, 1971). Black males apparently work in coast-related industries with many of the black women working in local fish canneries and seafood processing plants.

The outside elements influencing these communities must not be overlooked. Southern Terrebonne Parish is the site of some of the richest natural resources in the state (oil and gas). Hence there have been numerous legal contests over ownership of land, mineral rights, etc., between the original inhabitants and outside groups (Fischer, 1968). Because of the extensive ownership of land by oil interests, most of the property in the Dulac area is leased from these companies by residents.

Methodology

The Sample. Fifty percent of the households in the Dulac area and 25 percent of the households in the Grand Caillou/Bobtown area were selected for interviews (N=216). State highway maps, corrected by physical inspections of the areas, were used to determine the households to be interviewed. After randomly selecting the first household on each identifiable block, interviewers approached every other dwelling in the Dulac area and every fourth dwelling in the Grand Caillou/Bobtown area. The Dulac area was "over-sampled" to compensate for the fact that considerably fewer persons lived in the area. In cases of refusals or inability to contact residents, interviewers alternately selected residences on either side of the target household.

Local interviewers were selected because of the large number of residents who speak only French. Despite reservations about using indigenous interviewers, they were found to be very effective. They were conscientious, accurate, and most important, able to gain access to households where outsiders may have been less well received. Furthermore, the interviewers were able to establish accurately the racial identity of respondents, a task which would have been much more problematic for outsiders.

Assessment of Housing. An objective assessment of housing conditions was obtained by pictorially surveying resident dwellings. The technique used was developed by the Texas Department of Community Affairs (1973) and has been used to assess housing for the region in which the current study is located (South Central Planning and Development Commission, 1975).[3] The method involves visually assessing 10 external properties of dwellings: (1) appearance of neighborhood, (2) appearance of boundary of property, (3) appearance of lawn and shrubs, (4) condition of roof, (5) condition of exterior wall surfaces, (6) condition of front entryway, (7) condition of doors and trim around doors, (8) condition of windows and trim around windows, (9) evidence of electricity, and (10) evidence of plumbing. Each of these items is compared to a set of photographs from the Texas Housing Pictorial Survey which serve as the criteria for judging the quality of each. The photographs are ranked on a 7-point scale providing a basis for developing composite scores for each dwelling. To obtain data consistent with the previous research in the region, the assigned scores for each characteristic were weighted as done in the Louisiana survey (Appendix A). The cumulative total of these weighted scores represents the quality rating for each housing structure. These cumulative ratings were then categorized according to the scales used by the South Central Planning and Development Commission:

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[3] The South Central Planning and Development Commission covers six parishes: Assumption, St. James, St. John the Baptist, St. Charles, LaFourche, and Terrebonne. The housing assessment for this district was conducted by the Planning Commission in 1975.

1.0 - 2.4 = Good (Standard)
2.5 - 3.6 = Fair (Standard)
3.7 - 4.5 = Poor (Substandard)
4.6 - 7.0 = Dilapidated (Substandard)

Replication of these standard scores gave us a basis from which comparisons could be made of the communities studied relative to the region and parish.[4]

Housing data were also obtained from items on the interview schedule. Demographic data included family size, number of rooms, household items owned (i.e., refrigerator, air conditioning, etc.), ownership status, type of dwelling, and so on. Subjective assessments of dwellings were derived from responses to two questions: (1) "In general, how satisfied are you with your home?" Responses ranged from "very satisfied" to "very dissatisfied." (2) "Would you move to a better dwelling if provided?" Responses were either "yes" or "no" with an indication of where respondents would prefer to live if they answered "yes".

In addition to the structured interviews and housing assessment strategies, the authors visited homes and informally talked to a variety of residents. Although this aspect of the research cannot be accurately quantified, useful insights and information came to light which, as will be discussed later, supplemented and aided in the interpretation of the more quantifiable data.

Analysis of the Findings. Findings from the pictorial housing assessment and interview survey will first be presented descriptively. Region and parish data will be compared to the findings from the Dulac and Grand

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[4] These categories are defined as follows: Good—standard housing requiring little or no repair; Fair—standard housing requiring minor repair; Poor—substandard housing requiring major repair; and Dilapidated—substandard housing virtually beyond repair (South Central Planning and Development Commission, 1975). Although there may be some questions concerning the study conducted 1 year earlier, it was felt that (1) the instrument was sufficiently structured to allow reliable results across different researchers, and (2) housing conditions likely would not change significantly within a 1-year period.

Caillou/Bobtown communities when possible. Following this, factors related to housing conditions and subjective responses to housing will be explored in detail. This level of analysis will entail a variety of statistical techniques, to be discussed when used, as appropriate for the type of data and questions being addressed.

Findings

Comparing Objective Housing Conditions with Parish and Regional Data

The results of the housing assessment for the Grand Caillou and Dulac communities are presented with the results from the South Central Planning and Development Commission study for the region and Terrebonne Parish in Figure 1. These data suggest that although the physical condition of housing in Terrebonne Parish is comparable to the overall results for the six-parish region, the Grand Caillou/Bobtown and Dulac areas contain a substantially higher percentage of substandard housing (defined as poor or

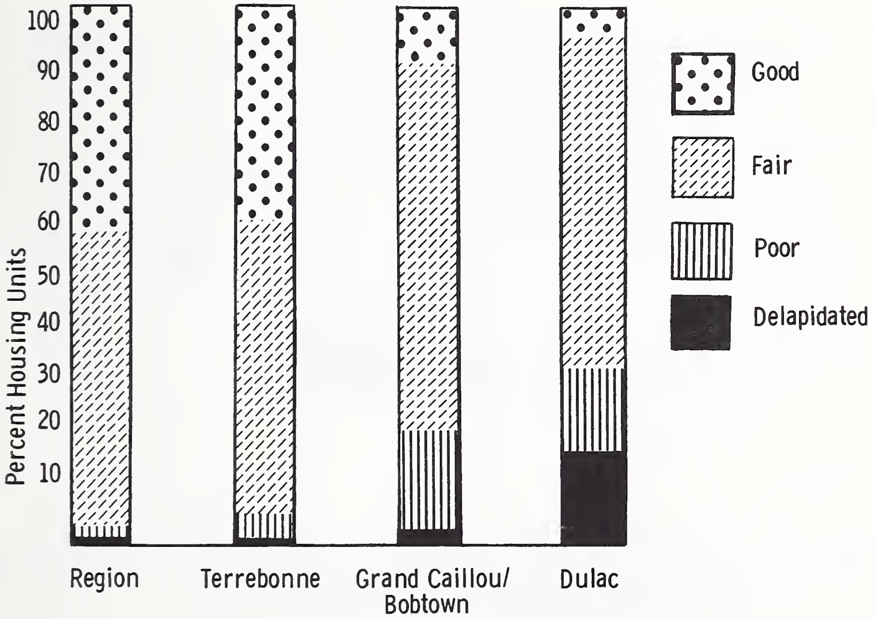

Figure 1.- Condition of housing units for region[1], Terrebonne Parish[1], Grand Caillou/Bobtown[2], and Dulac[2].

[1]Source: South Central Planning and Development Commission, 1975. Region includes Assumption, St. James, St. John the Baptist, St. Charles, LaFourche, and Terrebonne parishes.

[2]Source: Survey by authors, 1976.

dilapidated). There is also a noticeable difference between the two community areas with the housing in Dulac rated notably more substandard than the housing in Grand Caillou/Bobtown.

The condition of housing units by race (nonwhites vs. white)[5] is compared with regional data in Figure 2. There is a distinct difference between white and nonwhite housing quality in each of the areas with the white housing units consistently scoring higher than nonwhite housing units. These results indicate that the lower quality of housing in the Grand Caillou/Bobtown and Dulac communities is not necessarily due to a preponderance of minority residents in the area. The quality of housing is lower for both whites and nonwhites when compared to the region.

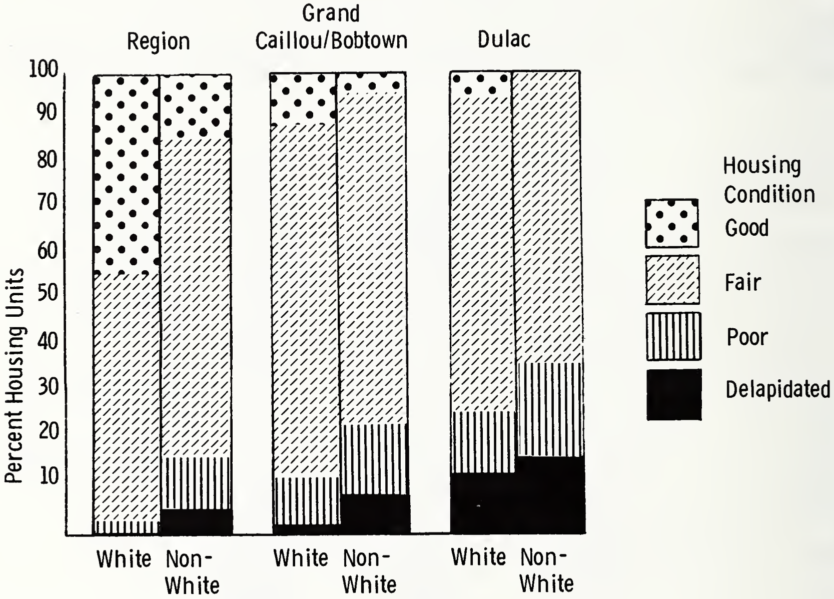

Figure 2. - Condition of housing units for region[1], Grand Caillou/Bobtown[2], and Dulac[2] for white and non-white residents.

[1]Source: South Central Planning and Development Commission, 1975. Region includes Assumption, St. James, St. John the Baptist, St. Charles, LaFourche, and Terrebonne parishes.

[2]Source: Survey by authors, 1976.

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[5] Black and Indian respondents were collapsed into a "nonwhite" subgroup in order to conform to the regional data which reflects these two categories.

Table 2.—Percent of combined Grand Caillou/Bobtown and Dulac area residents living in high, medium, and low-rated dwellings by race, 1976

	Condition of Dwelling (Score)		
	High	Medium	Low
Race	Percent (n)	Percent (n)	Percent (n)
White	50.6 (42)	19.3 (16)	30.1 (25)
Indian	17.2 (20)	39.7 (46)	43.1 (50)
Black	5.9 (1)	29.4 (5)	64.7 (11)

$X^2 = 33.304$, 4DF, $p<.0001$.

In order to statistically assess the nature of differences in quality of housing across racial groups, house ratings have been trichotomized into high, medium, and low categories.[6] Table 2 presents the results of chi square analysis for housing condition by race. As can be seen, there is a wide disparity in housing conditions between racial groups ($X^2=33.304$, $p<0.0001$).

Mobile Homes. One important aspect of the housing situation in the Grand Caillou/Bobtown and Dulac communities is the high percentage of mobile homes: about 27 percent in Grand Caillou/Bobtown and 47 percent in Dulac. As depicted in Figure 3, the preponderance of mobile homes fall in the standard category and therefore can be considered a major contributor to the overall percentage of housing rated as standard. This effect is most marked for the nonwhite housing in both community areas, especially in Dulac. Taking mobile homes into consideration in the housing assessment (Figure 3), the percentage of substandard houses increases substantially for frame houses. Over half of the frame houses in Dulac, for example, are rated substandard. It is clear that in terms of the criteria used to rate these dwellings, the presence of mobile homes contributes to more positive overall scores.[7]

Other Objective Housing-Related Factors

Density. The U.S. Bureau of Census defines overcrowding as a condition where there is more than one person per room for a housing unit. Data in Figure 4 for density (persons per room) for the Dulac and Grand

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[6] This was accomplished by dividing the distribution of scores for the entire sample into three groups with approximately equal numbers of scores.

[7] Results of a T-test for differences between mean condition scores of mobile homes and frame houses support this observation: mobile home mean score = 3.18, frame house mean score = 3.37, $T = -2.806$, $p<0.01$.

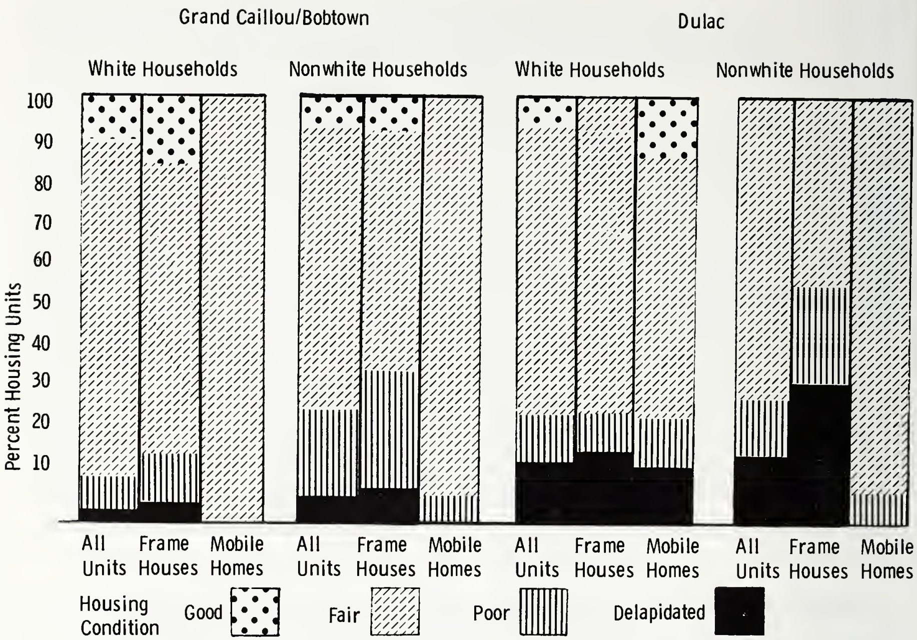

Figure 3.- Condition of housing units by race and type of dwelling for Grand Caillou/ Bobtown and Dulac[1].

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[1] Source: Survey by authors, 1976.

Caillou/Bobtown communities is based upon the present survey and data for the region from the South Central Planning and Development Commission survey (1975). These findings indicate that the level of crowding is comparatively high for nonwhites in both the region and target communities. The differences across district and community areas, however, are not extreme. It is interesting to note that while the two categories representing the highest density reflect almost one-fourth of the Dulac Indian households, this same group has the largest percentage of noncrowded units for nonwhites. The differences in density noted between races is partially explained by differential family sizes. Data in Table 3 show that the nonwhite households are much more likely than white households to have large families.

Family Income.[8] The results presented in Table 4 represent 77.3 percent of the sampled households which were willing to report income range. These findings suggest that the black families reported substantially lower incomes than either Indian or white families. About 65 percent of the black

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[8] Because family income was not included in the Regional survey, only results from our sample are included here.

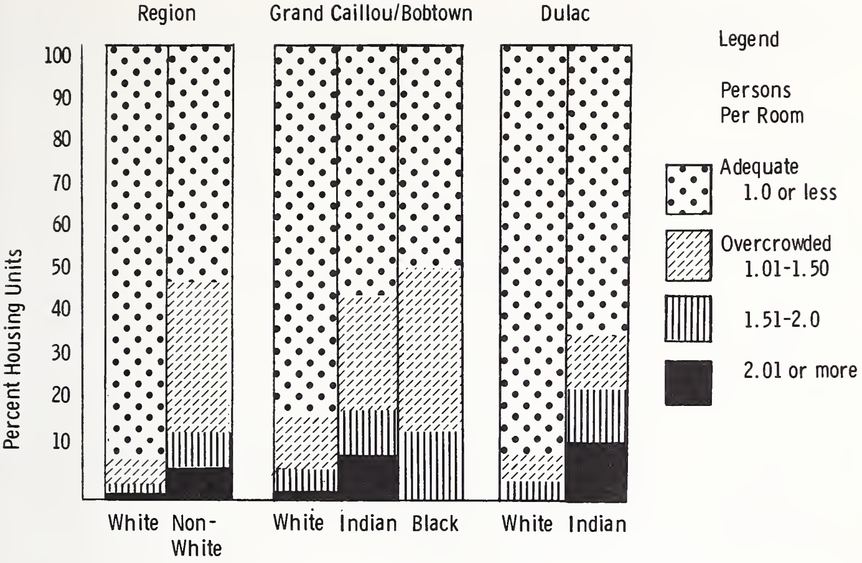

Figure 4.- Persons per room for region[1], Grand Caillou/Bobtown[2], and Dulac by race.

[1] Source: South Central Planning and Development Commission, 1975. Region includes Assumption, St. James, St. John the Baptist, St. Charles, Lafourche, and Terrebonne parishes.

[2] Source: Survey by authors, 1976.

Table 3.—Number of persons per household in combined Grand Caillou/Bobtown and Dulac communities[1] and the U.S.[2] by race

Number of Persons In Household	White		Nonwhite				Totals		U.S., 1974
			Indian		Black				
	Percent	(n)	Percent	(n)	Percent	(n)	Percent	(n)	
1-2	24.4	(20)	14.8	(17)	11.1	(2)	18.1	(39)	49.8
3-4	50.0	(41)	31.3	(36)	27.8	(5)	38.1	(82)	32.7
5-6	17.1	(14)	25.2	(29)	50.0	(9)	24.2	(52)	13.7
7+	8.5	(7)	28.7	(33)	11.1	(2)	19.6	(42)	3.8
Totals	100%	(82)	100%	(115)	100%	(18)	100%	(215)	100%
Mean Number per Household	3.8		5.2		5.0				

[1] Source: Survey by Authors, 1976.

[2] Source: U.S. Bureau of the Census, *Statistical Abstract of the United States: 1975*.

Table 4.—Reported family income categories[1] for residents of Grand Caillou/Bobtown and Dulac[2] by race

INCOME RANGE	RACE						TOTALS	
	White		Nonwhite					
			Indian		Black			
	Percent	(n)	Percent	(n)	Percent	(n)	Percent	(n)
Under $5,000	29.3	(17)	24.7	(21)	64.7	(11)	30.6	(49)
$5,000-9,999	22.4	(13)	37.6	(32)	23.5	(4)	30.6	(49)
$10,000-14,999	27.6	(16)	25.9	(22)	5.9	(1)	24.5	(39)
$15,000-19,999	12.1	(7)	10.6	(9)	5.9	(1)	10.6	(17)
$20,000 or more	8.6	(5)	1.2	(1)	0.0	(0)	3.7	(6)
GRAND TOTALS	100.0	(58)	100.0	(85)	100.0	(17)	100.0	(160)

[1] 77.3% of the respondents reported their income range.

[2] Source: Survey by authors, 1976.

families reported annual incomes under $5,000 as compared to 25 percent for Indian and 29.3 percent for white respondents. At the higher income levels about 21 percent of the white households reported incomes over $15,000 as compared to about 12 percent of the Indian and 6 percent of the black households.

Household Conveniences. Respondents were asked to indicate ownership of a number of household conveniences. As can be seen in Table 5, the general tendency is for white households to report ownership of such items more frequently than nonwhite households. Nearly all households reported having such amenities as piped water, gas or electric range, electricity, and refrigerators. Ownership dropped off considerably for such items as vacuum cleaners, sewing machines, and central heat.

Employment of Heads of Households. Employment status (Table 6) reflects a relatively high level of unemployment for heads of households (23.9 percent). Subtracting the retired category still results in an overall 16.3 percent unemployment rate for sampled households (7.7 percent for white, 18.6 percent for Indian, and 38.9 percent for black heads of households). Interestingly, about one-third of the black heads of households reported unemployment due to disabilities. This compares to 8 percent for Indian and 5.1 percent for white unemployed heads of households reporting disabilities. The majority of employed heads of households for all races are salaried or hourly paid employees.

Table 5.—Percentage of Grand Caillou/Bobtown and Dulac households owning conveniences by race[1]

Household Items	White		Non-white				Total	
			Indians		Blacks			
	Percent	(n)	Percent	(n)	Percent	(n)	Percent	(n)
1. Electricity	98.8	(82)	100.0	(116)	100.0	(17)	99.6	(215)
2. Gas or Electric Range	98.8	(82)	97.4	(113)	100.0	(17)	98.7	(212)
3. Piped Water	98.8	(82)	96.6	(112)	94.1	(16)	96.5	(210)
4. Mechanical Refrigerator	95.2	(79)	87.1	(101)	100.0	(17)	94.1	(197)
5. Bath/Shower	95.2	(79)	87.9	(102)	94.1	(16)	92.4	(197)
6. Inside Flush Toilet	95.2	(79)	87.9	(102)	94.1	(16)	92.4	(197)
7. Septic Tank	80.0	(66)	78.4	(91)	94.1	(16)	84.2	(173)
8. Washing Machine	96.4	(80)	85.3	(99)	64.7	(11)	82.1	(190)
9. Hot Water Heater	88.0	(73)	75.0	(87)	82.4	(14)	81.8	(174)
10. Telephone	90.4	(75)	63.8	(74)	82.4	(14)	78.9	(163)
11. Freezer	81.9	(68)	46.6	(54)	76.5	(13)	68.3	(135)
12. Air Conditioner	81.9	(68)	56.9	(66)	58.8	(10)	65.9	(144)
13. Clothes Dryer	83.1	(69)	62.9	(73)	46.1	(8)	64.4	(150)
14. Color T.V.	75.9	(63)	49.1	(57)	47.1	(8)	57.4	(128)
15. Black & White T.V.	43.4	(36)	50.9	(59)	76.5	(13)	56.9	(108)
16. Sewing Machine	72.3	(60)	45.7	(53)	47.1	(8)	55.0	(121)
17. Vacuum Cleaner	68.7	(57)	37.1	(43)	23.5	(4)	43.1	(104)
18. Central Heat	49.4	(41)	32.8	(38)	23.5	(4)	35.2	(83)
19. Dishwasher	8.4	(7)	6.0	(7)	5.9	(1)	6.8	(15)

[1] Source: Survey by authors, 1976.

Age of Heads of Households and Spouses. As shown by Table 7, there is a noticeable differential distribution of age across races for the community areas. The most evident feature of this age distribution is the fact that the Indian households are headed by younger adults than either black or white households. Looking at heads and spouses combined, 58.6 percent of the Indian residents are under 35 while 30.6 percent of the white and only 9.4 percent of the black respondents fall in this age group. At the older end of the age scale the black and the white households are composed similarly (21.9 percent and 22.5 percent respectively being 55 years or over), while only 15.2 percent of the Indian adults fall in the 55 or over category.

Table 6.—Employment status of Grand Caillou/Bobtown and Dulac heads of households by race[1]

EMPLOYMENT STATUS	RACE						TOTALS	
	White		Non-white					
			Indian		Black			
	Percent	(n)	Percent	(n)	Percent	(n)	Percent	(n)
FULL TIME	77.0	(60)	73.4	(83)	38.9	(7)	71.8	(150)
Self-employed	19.2	(15)	15.0	(17)	5.6	(1)	15.8	(33)
Salaried/Hourly	48.7	(38)	41.6	(47)	33.3	(6)	43.5	(91)
Seasonal	9.0	(7)	16.8	(19)	0.0	(0)	12.4	(26)
PART TIME	1.3	(1)	3.5	(4)	22.2	(4)	4.3	(9)
Continuous	0.0	(0)	1.8	(2)	0.0	(0)	1	(2)
Seasonal	1.3	(1)	1.8	(2)	22.2	(4)	3.3	(7)
NOT EMPLOYED	21.8	(17)	23.0	(26)	38.9	(7)	23.9	(50)
Disabled	5.1	(4)	8.0	(9)	33.3	(6)	9.1	(19)
Retired	14.1	(11)	4.4	(5)	0.0	(0)	7.6	(16)
Other	2.6	(2)	10.6	(12)	5.6	(1)	7.2	(15)
TOTALS	100%	(78)	100%	(113)	100%	(18)	100%	(209)

[1] Source: Survey by authors, 1976.

Education of Heads of Households and Spouses. The data suggest that the educational attainment level for heads of households and spouses is low in all households and especially low for nonwhite residents (Table 8). Indian heads of households reflect the lowest educational level with 28.2 percent of this group indicating no formal education at all. Only a small percent of the total sample indicated educational experiences beyond high school (3.4 percent of the white, 0.5 percent of the Indian, and 3.1 percent of the black respondents).

Correlates of Housing Condition

In order to obtain a better understanding of the relationship between housing conditions and various other factors discussed above, some simple statistical measures of correlation have been applied and the findings graphically presented. It should be noted that the following graphs depict simple relationships and that no statistical controls for a variety of potential intervening variables have been attempted.

Housing Condition and Size of Family. Because family size (i.e., number of persons living in a household) and the number of persons per room are very closely related, only findings for size of family relative to

Table 7.—Age of Grand Caillou/Bobtown and Dulac heads of households and spouse by race[1]

	Heads (N = 186)						Homemakers or Spouses (N = 184)						Combined Totals (N = 370)					
			Non-white						Non-white						Non-white			
AGE	White		Indian		Black		White		Indian		Black		White		Indian		Black	
18-24	06.5	(5)	16.5	(15)	—	(0)	12.9	(9)	23.0	(23)	—	(0)	9.5	(14)	19.9	(38)	—	(0)
25-34	20.8	(16)	37.4	(34)	5.6	(1)	21.4	(15)	40.0	(40)	14.3	(2)	21.1	(31)	38.7	(74)	9.4	(3)
35-44	24.7	(19)	4.4	(4)	22.8	(4)	22.8	(16)	21.0	(21)	64.3	(9)	23.8	(35)	13.1	(25)	40.6	(13)
45-54	22.0	(17)	20.9	(19)	44.4	(8)	24.3	(17)	06.0	(6)	7.1	(1)	23.1	(34)	13.1	(25)	28.1	(9)
55-64	15.6	(12)	13.2	(12)	22.2	(4)	12.9	(9)	7.0	(7)	14.3	(2)	14.3	(21)	10.0	(19)	18.8	(6)
65 and over	10.4	(8)	7.7	(7)	5.6	(1)	5.7	(4)	3.0	(3)	—	(0)	8.2	(12)	5.2	(10)	3.1	(1)
TOTAL	100.0	(77)	100.0	(91)	100.0	(18)	100.0	(70)	100.0	(100)	100.0	(14)	100.0	(147)	100.0	(191)	100.0	(32)

[1] Source: Survey by authors, 1976.

Table 8.—Education of Grand Caillou/Bobtown and Dulac heads of households and spouses by race[1]

	HEADS OF HOUSEHOLDS						SPOUSES						TOTALS					
			Nonwhite						Nonwhite						Nonwhite			
Years of School	White		Indian		Black		White		Indian		Black		White		Indian		Black	
0	12.8%	(10)	28.2%	(31)	27.8%	(5)	7.1%	(5)	13.9%	(14)	7.1%	(1)	10.2%	(15)	21.3%	(45)	18.8%	(6)
1-3	9.0	(7)	13.6	(15)	—	(0)	7.1	(5)	11.9	(12)	—	(0)	8.2	(12)	12.8	(27)	—	(0)
4-6	24.4	(19)	21.8	(24)	27.8	(5)	20.0	(14)	32.7	(33)	7.1	(1)	22.4	(33)	27.0	(57)	18.8	(6)
7-9	20.5	(16)	21.8	(24)	33.3	(6)	21.5	(15)	24.7	(25)	28.7	(4)	21.1	(31)	23.2	(49)	31.2	(10)
10-12	28.2	(22)	14.6	(16)	11.1	(2)	41.4	(29)	15.8	(16)	50.0	(7)	34.7	(51)	15.2	(32)	28.1	(9)
Beyond High School	5.1	(4)	—	(0)	—	(0)	2.9	(2)	1.0	(1)	7.1	(1)	3.4	(5)	0.5	(1)	3.1	(1)
TOTALS	100.0	(78)	100.0	(110)	100.0	(18)	100.0	(70)	100.0	(101)	100.0	(14)	100.0	(147)	100.0	(211)	100.0	(32)

[1] Source: Survey by authors, 1976.

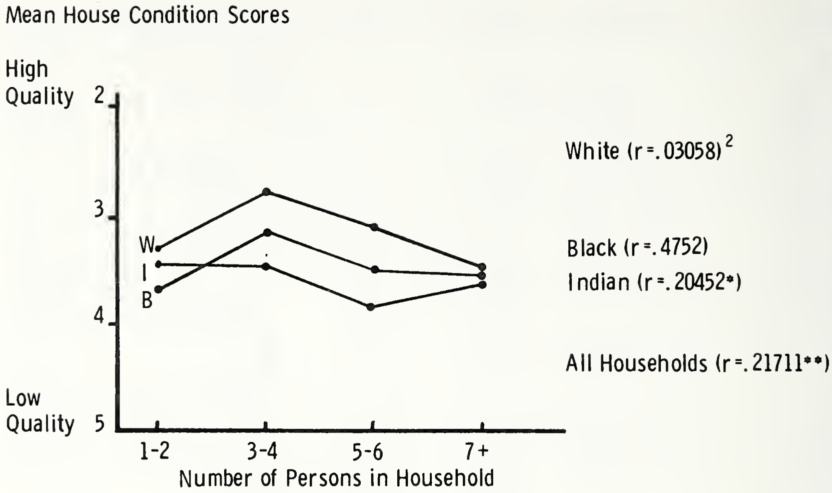

Figure 5.- Mean house condition scores for Grand Caillou/Bobtown and Dulac by size of household and race.[1]

[1] Source: Survey by authors, 1976.

[2] Pearson correlation coefficients calculated from number of persons in households by mean house condition scores. Positive correlation coefficients reflect negative associations.

$^{*}p<.05$, $^{**}p<.01$.

housing conditions are reported. These data are presented in Figure 5 by race. When all residents are combined, family size is negatively correlated to housing condition ($r=0.21711$, $p<0.01$).[9] That is, as the size of families increases, there tends to be a decrease in the quality of the dwellings. This effect becomes diffused when race is controlled. As is shown in Figure 5, the degree of association drops for each group with the Indian households maintaining the only statistically significant correlation ($r=0.20452$, $p<0.05$) and the white households displaying essentially no correlation $r=0.03058$, p=n.s.). The data suggest that housing conditions tend to be rated highest for three- to four-member families.

Housing Condition and Family Income. Although it would seem likely that family income would have a direct impact on the condition of housing, the findings presented in Figure 6 show that the relationship is weak at best. When all groups are combined there appears to be very little correlation between income and housing condition ($r=-0.08598$, p=n.s.). The results for each racial group suggest that only the black

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[9] Because lower housing condition scores indicate higher quality housing, positive correlation coefficients reflect negative associations and negative correlation coefficients reflect positive associations.

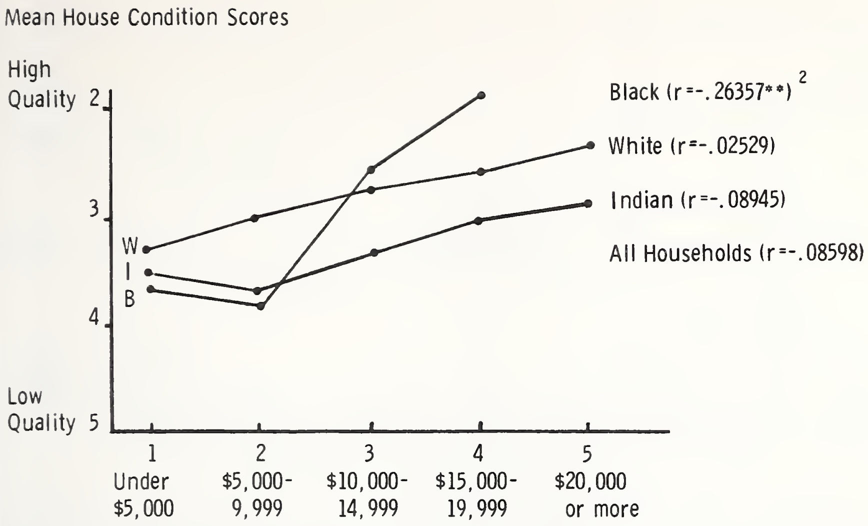

Figure 6.- Mean house condition scores for Grand Caillou/Bobtown and Dulac by income category and race.[1]

[1]Source: Survey by authors, 1976.

[2]Spearman correlation coefficients calculated from income categories by mean house condition scores. Negative correlation coefficients reflect positive associations.

** p<.01

households are affected by income (r=0.26357, p<.01). Because of the small frequency of black households in the upper income brackets, statistical findings are inconclusive for this group.

Housing Condition and Age of Head of Household. The findings regarding the association between the age of heads of households and the condition of housing are interesting. The combined sample results suggest that age is negatively correlated to housing condition (r=0.14512, p<.05), that is, as the age of the head of the household increases, the quality of dwelling decreases. This finding is largely due to the nonwhite residents in the sample, as can be seen in Figure 7. While the white respondents show almost no correlation between age and housing conditions (r=0.00499, p=n.s.), the Indian dwellings definitely decline in quality with the age of the head of the household (r=0.29642, p<.01) as do the black dwellings (r=0.25384, p=n.s.). A probable reason for this decline, as mentioned earlier, is the preponderance of mobile homes for younger residents. Because the quality of mobile homes tends to inflate the overall quality of housing, it would follow that housing quality would decline as the age of the resident increases.

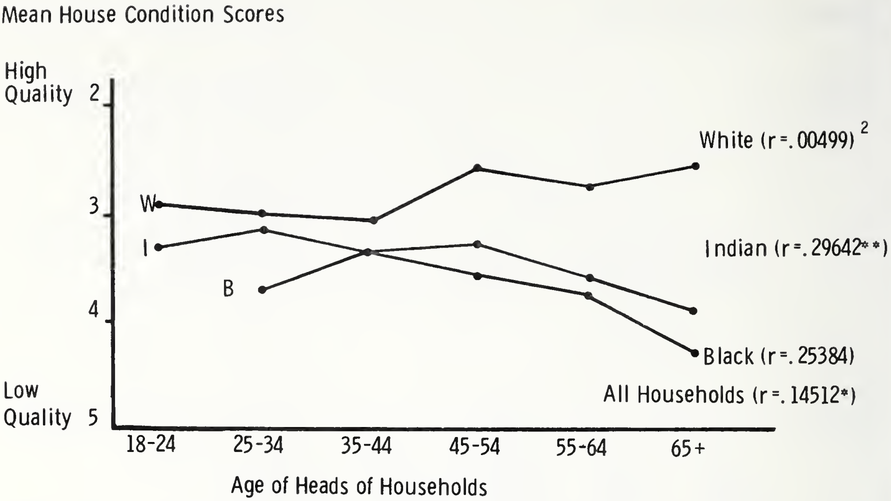

Figure 7.- Mean house condition scores for Grand Caillou/Bobtown and Dulac by age of heads of households and race.[1]

[1] Source: Survey by authors, 1976.

[2] Pearson correlation coefficients calculated from age of heads of households by mean house condition scores. Positive correlation coefficients reflect negative associations.

*p<.05, **p<.01.

Housing Condition and Education of Head of Household. The findings for the relationship between educational attainment of heads of households and dwelling conditions are reported in Figure 8. There is a relatively high positive correlation between educational attainment and condition of dwelling when all subjects are considered (r=-0.26996, p<0.0001). Unlike previous relationships, however, this effect is most predominant for the Indian households (r=-0.26357, p<0.01) and the white households (r=-0.22489, p<0.05). Educational attainment appears to have little impact on housing condition for blacks in the sample (r=0.19048, p=n.s.) and is slightly negative in direction.

Subjective Factors Relative to Housing

Findings concerning residents' subjective responses to their living circumstances in the Dulac and Grand Caillou communities are reported in this section. Two major subjective indicators are examined: satisfaction with dwelling and preferences to move.

Satisfaction with Dwelling. The survey results indicate that residents are by and large satisfied with their present dwellings. Although the

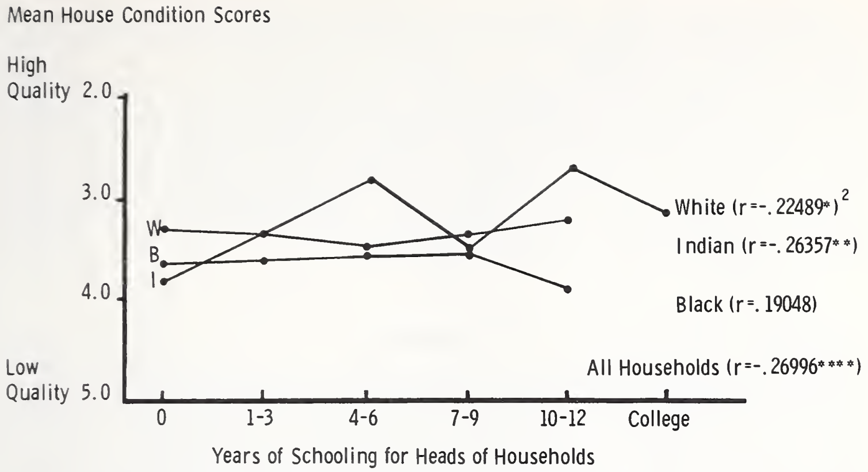

Figure 8.- Mean house condition scores for Grand Caillou/Bobtown and Dulac by education of heads of households and race.[1]

[1] Source: Survey by authors, 1976.

[2] Pearson correlation coefficients calculated from number of years of schooling of heads of households by mean house condition scores. Negative correlation coefficients reflect positive associations.

*$p<.05$, **$p<.01$, ****$p<.0001$.

responses tended to be quite positive across racial groups, white residents were "very satisfied" with their houses about 20 percent more often than nonwhite residents. The last three satisfaction categories have been collapsed into "less than satisfied" for presentation in Table 9. Results for chi square analysis reveal a statistically significant difference among races for satisfaction with dwelling ($X^2=9.488$, $p<0.05$).

Table 9.—Satisfaction of Grand Caillou/Bobtown and Dulac residents with dwelling by race[1]

	RACE							
			Nonwhite					
HOUSING SATISFACTION	White		Indian		Black		TOTALS	
	%	(n)	%	(n)	%	(n)	%	(n)
Very Satisfied	65.9	(54)	46.6	(54)	35.3	(6)	53.0	(114)
Satisfied	25.6	(21)	35.3	(41)	52.9	(9)	33.0	(71)
Less Than Satisfied	8.5	(7)	18.1	(21)	11.8	(2)	14.0	(30)
TOTALS	100.0	(82)	100.0	(115)	100.0	(17)	100.0	(215)

$X^2=9.488$, DF=4, $p<0.05$.

[1] Source: Survey by authors, 1976.

Preferences to Move. When asked if they would move if better dwelling were provided, about half of the residents answered "no" (51.2 percent, Table 10), supporting the observation that residents tend to be satisfied with their housing. As with the satisfaction findings, white residents were more likely to prefer their present dwellings (63.8 percent) than Indian (47.4 percent) or black (17.7 percent) residents. Results of chi square analysis reveal that the differences are statistically significant ($X^2=14.625$, DF=4, $p<0.01$; Table 10).

Correlates of Satisfaction with Dwelling

Similar to the exploration of various factors potentially related to housing conditions, findings regarding relationships between certain household variables and residents' satisfaction with their dwelling are explored. Specifically findings are presented for the relationship between house satisfaction and family size, income, age, and educational attainment level of heads of households. It should be kept in mind that the overall satisfaction rate is relatively high and the variance is small.

Family Size and Satisfaction with Dwelling. The data shown in Figure 9 indicate that the impact of the size of a resident's family upon subjective responses to the dwelling unit is negligible. Findings for the combined sample and for the racial groups separately reveal no statistically significant correlations. It is interesting to note that the Indian residents' assessment of their dwellings tend to slightly decline with size of family just as it was found earlier that housing conditions for Indian households declined with family size (Figure 5).

Table 10.—Preferences of Grand Caillou/Bobtown and Dulac residents to move by race[1]

	WOULD YOU MOVE IF A BETTER DWELLING WERE PROVIDED?							
			YES					
	NO		In or Near This Community		Elsewhere		TOTALS	
RACE	Percent	(n)	Percent	(n)	Percent	(n)	Percent	(n)
White	63.8	(51)	20.0	(16)	16.25	(13)	54.5	(116)
Nonwhite								
Indian	47.4	(55)	29.3	(34)	23.30	(27)	37.5	(80)
Black	17.7	(3)	35.3	(6)	47.10	(8)	8.0	(17)
TOTALS	51.2	(109)	26.3	(56)	22.50	(48)	(100.0)	(213)

$X^2=14.625$, DF=4, $p<0.01$.

[1] Source: Survey by authors, 1976.

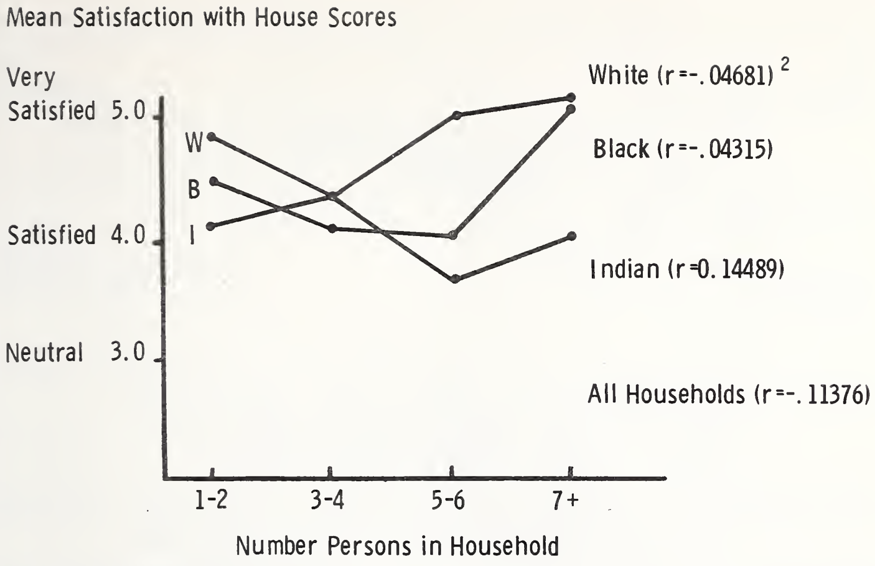

Figure 9.- Mean satisfaction with house scores for Grand Caillou/Bobtown and Dulac by size of family and race.[1]

[1] Source: Survey by authors, 1976.

[2] Pearson correlation coefficients calculated from number of persons reported in households by mean scores for satisfaction with house.

Income and Satisfaction with Dwelling. The findings indicate that family income level has very little impact on housing satisfaction. The correlation coefficients presented in Figure 10 are based upon absolute income, as opposed to income categories, reflecting very low levels of correlation between satisfaction and income. These findings tend to correspond with the relationships found between income and housing conditions shown in Figure 6.

Satisfaction with Dwelling and Age of Head of Household. Several observations can be made about the relationship between age of the head of household and satisfaction with dwelling (Figure 11). Overall, there is a tendency for age to be positively correlated with housing satisfaction (r=.21877, p<.01). The white residents of the communities sampled reflect a rather strong relationship between age and satisfaction (r=.35277, p<.01) while the findings for Indian residents reveal very little relationship (r=.15844, p=n.s.). Conversely, the black respondents tend to be less satisfied with their dwelling as age increases (r=.33948, p=n.s.). Recalling the relationships shown between age of head of household and housing condition (Figure 7), the satisfaction patterns are quite dissimilar to the

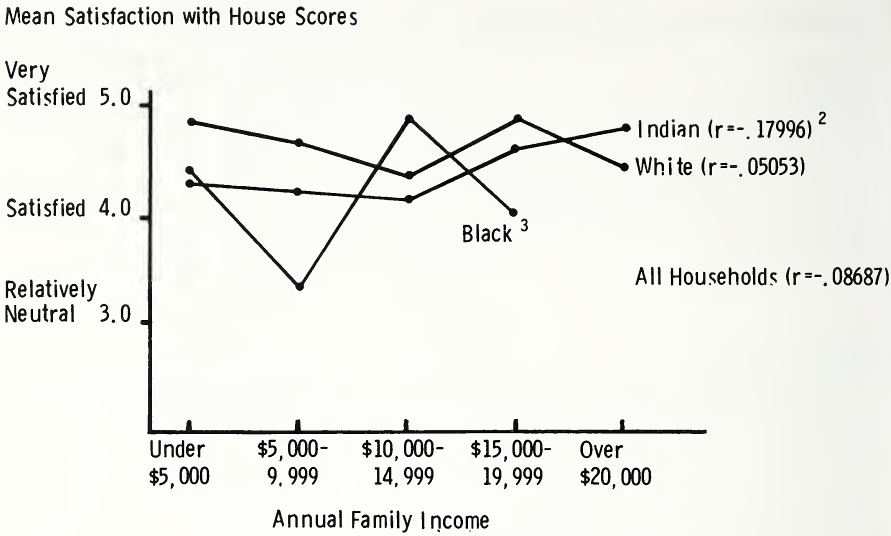

Figure 10.- Mean scores for satisfaction with house by Grand Caillou/Bobtown and Dulac residents by annual income and race.[1]

[1] Source: Survey by authors, 1976.

[2] Pearson correlation coefficients calculated from reported family income by mean scores for satisfaction with house.

[3] Insufficient data are available for black household incomes to calculate correlation coefficients.

condition patterns. That is, while the condition of housing tends to be negatively related to age for Indian residents, satisfaction does not seem to be affected by age. On the other hand, our data indicate that the condition of white dwellings is not related to age, while age seems to be related to subjective responses to housing. Data for the black residents are consistent for the two sets of relationships; the condition of housing, as well as satisfaction with housing, tends to decline with age of the head of household (although the correlation coefficients are not statistically significant for either relationship).

Satisfaction with Dwelling and Education of Head of Household. The relationship between level of education and resident satisfaction with housing is depicted by Figure 12. Although the correlation coefficient for this relationship for the total sample is negligible, when race is taken into account there is a distinct negative correlation for white respondents, as compared to positive correlations for the nonwhite respondents. These findings are especially interesting in the context of the findings for the relationship between housing condition and education of head of household

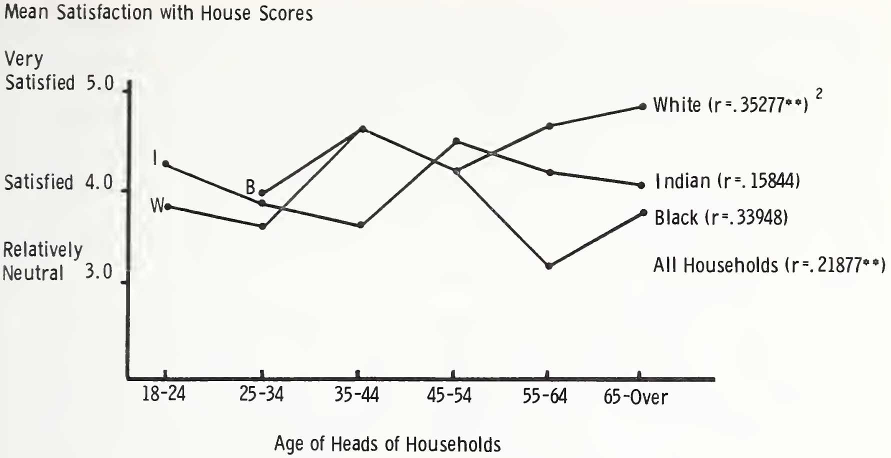

Figure 11.- Mean scores for satisfaction with house of Grand Caillou/Bobtown and Dulac residents by age of heads of households and race.[1]

[1] Source: Survey by authors, 1976.

[2] Pearson correlation coefficients calculated from age of heads of households by mean scores for satisfaction with house.

*p<.05. **p<.01.

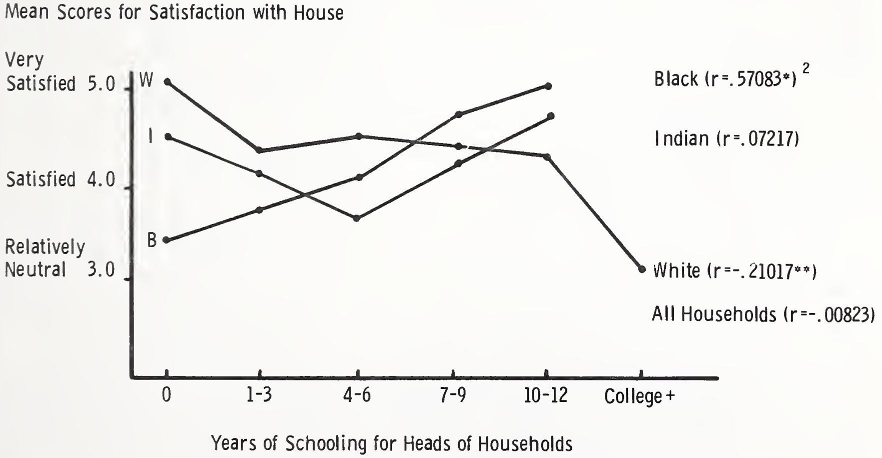

Figure 12.- Mean scores for satisfaction with house by Grand Caillou/Bobtown and Dulac residents by education of heads of households and race.[1]

[1] Source: Survey by authors, 1976

[2] Pearson correlation coefficients calculated from number of years of schooling of heads of households by mean satisfaction with house.

*p<.05, **p<.01.

(Figure 8) which depicted a positive relationship, especially for white and Indian households. It appears that while educational attainment is positively related to housing conditions for white residents, it is at the same time negatively related to subjective assessments of housing conditions. Educational attainment for Indian and black residents appears to result in more positive reactions to housing. One factor accentuating the impact of educational attainment is the observation that the college educated residents (of which there are no nonwhite respondents) are by far the most negative relative to housing satisfaction.

Housing Condition and Satisfaction with Dwelling. A central concern of this research has been the exploration of the relationships between subjective and objective aspects of housing. The condition of a resident's dwelling would seem to be very closely related to satisfaction with housing. However, our data suggest that this relationship is weak for those interviewed in the Dulac and Grand Caillou/Bobtown areas (Figure 13). No statistically notable relationship exists between the objective condition of housing and the resident's satisfaction with housing for the total sample or for any of the racial subgroups. These findings are congruent with our earlier observations which revealed little relationship between objective aspects of living environments and subjective responses.

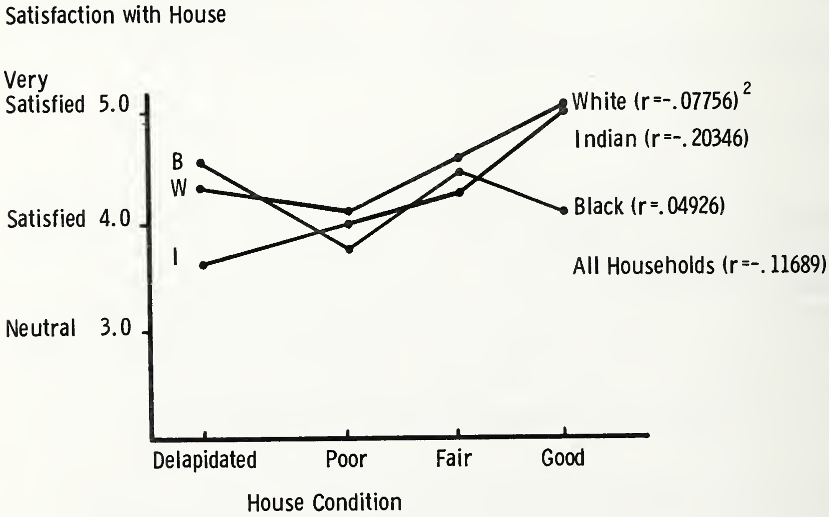

Figure 13.- Condition of housing of Grand Caillou/Bobtown and Dulac by mean scores for satisfaction with house and race.[1]

[1]Source: Survey by authors, 1976.

[2]Pearson correlation coefficients calculated from house condition scores and mean scores for satisfaction with house.

Informal Observations Relative to Housing. As mentioned earlier, a number of residents were informally interviewed in their homes. Although not amenable to quantification, this method provided relevant insights concerning the nature of resident orientations toward housing and supplemented data gathered from the structured interviews. Perhaps the most notable observation made by the researchers was the high standards of upkeep and cleanliness of the interiors of the dwellings, observations which were not always apparent from the outward condition of the dwellings. This observation tended to hold across racial groups.

Another factor worthy of mention was especially notable among the Indian residents. This is that there exists a strong sense of identity with the communities. The basis of this identity appears to be mainly tied to kinship patterns. It was repeatedly found that Indian residents could name virtually every Indian family in the area and could specify how each was related to the other.[10] It was apparent that the strong preferences (as shown in the survey) to remain in the immediate vicinity are largely influenced by these local ties.

Summary of the Findings

1. The overall quality of housing as determined by the procedures used in this study is substantially lower than the quality of housing for the six-parish region or for Terrebonne Parish as assessed by the South Central Planning and Development Commission (1975). This observation is true for both white and nonwhite dwellings, but the quality of nonwhite dwellings is markedly lower than white dwellings in the two communities.

2. The presence of a high percentage of mobile homes in the communities tends to upgrade the overall quality of housing. While nearly all of the mobile homes were rated in the standard category, a much lower percentage of frame houses were rated in this category. This effect is much more marked for the nonwhite households than for the white households because most of the mobile homes are owned by nonwhite families.

3. Although the level of crowding is high for households in the target communities, the data indicate that there is not much difference between the communities studied and the region as a whole. The nonwhite households reflect a much higher level of crowding than the white households largely because the nonwhite families tend to be larger than white families.

4. Based upon those reporting their income, the black households have substantially lower incomes than either Indian or white households. The

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[10] The importance of family and kinship ties has been substantiated by others (Fisher, 1968; Stanton, 1971; and Roy, 1959)

difference between Indian and white income levels is greatest in the upper brackets where 21 percent of the white households reported making over $15,000 in the last year while only 12 percent of the Indian households reporting incomes were in this category.

5. White households were found to possess a greater number of house-related conveniences than nonwhite households. However, very few families of any racial identity lack those items which can be considered to be most essential for everyday living (i.e., electricity, cooking range, piped water, refrigerator). Indian households possessed the fewest convenience items of the three groups surveyed.

6. Employment of heads of households for the two communities is about 72 percent. White heads of households account for the greatest proportion in the full time employed category. There were 73.4 percent of the Indian and 38.9 percent of the black heads of households who reported full time employment. Only 2.6 percent of the white heads of households reported being unemployed and neither disabled nor retired, while 10.6 percent of the Indian and 5.5 percent of the black heads of households reported this status. One third of the black heads of households reported being unable to work because of disabilities.

7. Indian heads of households and spouses tend to be younger than either black or white heads of households and spouses. The greatest number of Indian adults falls in the 25 to 34 year-old category while the white adults are fairly evenly distributed across the 25 to 34, 35 to 44, and 45 to 54 year-old categories and most black adults are in the 35 to 44 age category.

8. The education level of heads of households and spouses is low for all groups. No formal education is reported by 10.2 percent of white adults, 18.8 percent of black adults, and 21.3 percent of the Indian adults. Within each racial group males tend to have had less educational experience than females. This pattern is especially marked for the Indian respondents.

9. The condition of housing appears to be related to family size only for Indian households. As the family size increases there is a noticeable tendancy for the quality of Indian dwellings to decline.

10. There is no evident relationship between the quality of housing and the level of income for all residents surveyed. Although the findings show a statistical relationship for black family income and housing condition, there are an insufficient number of families in the upper income levels to allow confident conclusions concerning this observation.

11. Educational attainment appears to be related to the objective condition of housing for Indian and white households but not for black households. Higher educational levels of heads of households for these two groups is associated with higher quality of housing.

12. Overall, there is a relatively high level of satisfaction with housing

conditions among the respondents. Despite this high level of satisfaction, statistical analysis suggests that nonwhite respondents are significantly less satisfied than white respondents.

13. Similar to the findings for satisfaction with dwelling, a large percentage of the respondents reported that they would not move from their present dwellings if given the opportunity. The black respondents were most likely, the Indian respondents were next most likely, and the white respondents were least likely to report such preferences.

14. The data indicate that family size has little impact on satisfaction with dwelling. The finding is opposed to the finding noted earlier that family size and housing condition tend to be negatively related for Indian households.

15. Family income and satisfaction with dwelling are not statistically correlated. This is congruent with findings related to family income and housing condition.

16. Age and satisfaction with dwelling are most highly correlated for white residents. Older white residents tend to be more satisfied with their housing circumstances than younger white residents. Conversely, Indian residents tend to become less satisfied with their housing as age increases.

17. Level of education and satisfaction with housing appear to be positively related for nonwhite residents while having a markedly negative correlation for white residents. As noted earlier, education had no noticeable impact on condition of housing.

18. Although there is a tendancy for satisfaction with dwellings to be positively associated with the condition of residences, the data reveal no statistically significant associations for any of the racial subgroups.

Conclusions

The most salient observation concerning these findings is that the objective quality of housing definitely varies along racial lines. It is clear that Indian and black residents in these communities live in dwellings which are at least outwardly of lower quality than white dwellings in the communities. This is reflected by a number of indicators including physical appearance of dwellings, level of crowding, and the number of household goods possessed by residents.

The question which thus demands attention is what is it about being a member of a racial group that influences housing conditions. Two interrelated types of factors may shed some light on such a question. First, structural or objective circumstances can set limits on resident behavior or decisions regarding housing. That is, regardless of what persons may prefer in terms of housing, there may exist constraints which override preferences. Second, preferences or values themselves may influence decisions relative to housing conditions. Racial identity, for example, may be associated with personal standards about what is considered to be adequate or acceptable housing conditions and thus be reflected by the physical state of housing. The effects of such factors are not easily deciphered because of the multiplicity of variables which inevitably impinge upon individual behavior and personal orientations. However, based upon the findings of this study, probable factors related to housing conditions in the Grand Caillou/Bobtown and Dulac community areas can be suggested.

Several indicators in our findings which are associated with racial identity suggest that circumstances beyond individual volition are important factors in housing quality. Foremost in terms of available resources for upgrading housing is family income. The data indicate that black and Indian families are more likely to have lower incomes than white families. Furthermore, because nonwhite families tend to be significantly larger than white families, the economic resources available for housing would undoubtedly be proportionately reduced for nonwhite households. This contention is supported by the strong negative correlation between size of family and condition of housing, especially for Indian households (see Figure 5). Racial differences in educational attainment level further support this observation. The low level of educational attainment for nonwhite heads of households is very likely related to occupational mobility and earning capacity.

Two characteristics of the geographical setting of the communities which affect housing conditions should be reiterated. First, the fact that outside firms own much of the land in the lower part of the area (especially in Dulac, where the majority of Indian residents live) results in a situation where many residents must lease the land upon which their dwellings stand with no opportunity to own the land.[11] Therefore, even though they own their own homes, a substantial number of residents, especially Indian residents, have no long-term assurance of being able to retain their homes. Such circumstances undoubtedly would be important in any decisions to invest resources, either by residents or outside agencies, for upgrading housing quality.

The second geographical aspect relates to the peculiar topographical characteristics of the area. Surrounded by salt marshes and bayous, many homes are susceptible to periodic flooding. This has created problems—for example, with obtaining low interest federal loans because of insurance requirements that housing be a minimum height above flood levels. Thus, not only are structures likely to be damaged by natural elements, but outside resources for repairs are unavailable.

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[11] See Fisher (1968) for a detailed discussion of the land ownership problems of the Houma Indians.

The matter of personal values or orientations toward housing is more difficult to assess. Even though the survey does not address this problem in depth, some inferences can be made from the data. The level of satisfaction with housing, although relatively high for all respondents, tends to be lower for nonwhite than for white residents. It seems likely that this lower level of satisfaction implies a concern with the quality of housing. The findings relative to preferences to move to better dwellings in the area follow this same pattern. However, the lack of correlation between housing condition and satisfaction for any of the racial subgroups suggests that satisfaction may be determined by factors other than the physical quality of housing.

Based upon observations made during informal visits with residents, it could be argued that orientations to upkeep and maintenance of housing do not markedly differ among racial groups. As noted earlier, homes which could be considered to be overcrowded or inadequate from external appearances, were kept clean and comfortable. Residents tended to be concerned with the adequacy of their dwellings and demonstrated a certain amount of pride in managing with what they had available. Because of the strong desire to remain in their communities to be close to friends and relatives, there was little indication of preferences to move to other communities which might provide better housing.

In short, no evidence has been found that the variance in housing conditions across race are due to major differences in personal orientations toward housing. It appears that both white and nonwhite residents are concerned about their housing and that external factors (i.e., land ownership, geographical setting, economic resources, etc.) are major contributors to variations in housing. The assessment of housing in these communities, therefore, is more complex than concerns with the physical quality of the dwellings. The interrelatedness of economic, cultural, and geographical circumstances creates a situation whereby housing assessments cannot be divorced from the uniqueness of the community setting.

Appendix A

Measuring Housing Quality

The technique of assessing the physical quality of housing in this study is based upon information from the Texas Department of Community Affairs handbook *Housing Data Collection* (1973). This procedure was initiated in an effort to overcome serious limitations in U.S. Bureau of Census attempts to classify physical quality of housing as "standard," "deteriorating," or "dilapidated." Such a semantic scheme proved to be so problematic for field interviewers, since a number of considerations had to be synthesized into one classificatory scheme, that the Census Bureau decided to drop this classification for the 1970 census. Although other attempts at classifying housing based upon semantic scales have been made, the Texas housing study incorporated the use of photographs depicting 10 characteristics of housing to be used as bases for evaluating housing quality. Three photographs for each characteristic are arranged as a seven-point scale, positioned at two, four, and six, respectively, permitting interpolation of grading at points one, three, five, or seven. Field researchers are instructed to score selected housing units on each of the 10 characteristics by matching the photographs most nearly depicting the particular characteristic being evaluated at each housing unit.

The advantages of this procedure are enumerated in the Texas handbook:

> Use of this technique tended to overcome the most serious limitations of the semantic scales. First, the pictorial scale used no words to describe the quality of the characteristic being evaluated. Without using words such as "standard" or "dilapidated," the field interviewer needed only very limited training to be able to match what was seen in a housing unit to the sample photographs — or else to interpolate between two sample photographs on the scale.
>
> Second, the pictorial scale did not require the field interviewer to balance off-setting characteristics and make a summary judgment of classification in a single, all-encompassing term. Instead, each of the 10 characteristics was scored independently, and a uniform weighting procedure subsequently determined a composite score during the data processing phase of the study.
>
> Finally, the pictorial scale yielded a technique capable of use on a broad scale at reasonable cost, since highly technical field personnel are not required. Also, the technique is stable enough in its format to permit replication of the study at different places or at later times for purposes of comparative analysis. (Office of the Governor of Texas and Texas Department of Community Affairs, 1974:8)

The scores for each housing characteristic have been weighted according to the weights developed by the Texas study. This procedure was used because the Louisiana regional housing study applied the Texas weights and comparability between findings in Louisiana was desired. Ideally, the weighting scheme would be based upon the aggregate scores for each separate study.

Due to the unique geographical setting of the communities in this study, the scoring scheme was slightly modified. The housing units in these communities are located in linear patterns along bayous which results in homogeneity of neighborhood appearance and property boundaries; therefore, these two characteristics were not included in the scoring procedures. In order to arrive at scores comparable to the Texas and Louisiana results, the weights of these two characteristics were summed and then divided by eight. This was then added to each of the remaining eight characteristic weights to proportionately increase the scores to the original range of possible scale scores. Thus, the total score for each unit remains between one and seven, where one is the highest possible quality score and seven is the lowest. Table 11 presents the adjusted weights by characteristics.

Table 11.—Table of weights

HOUSING ITEM	ORIGINAL WEIGHTS[1]	ADJUSTED WEIGHTS (Original Weight + .021)
1. Appearance of Neighborhood	.086	——
2. Appearance of Boundary of Property	.080	——
3. Appearance of Lawn and Shrubs	.107	.128
4. Condition of Roof	.121	.142
5. Condition of Exterior Wall Surfaces	.122	.143
6. Condition of Porch and Front Entryway	.117	.138
7. Condition of Door and Trim Around Doors	.130	.151
8. Condition of Windows and Trim Around Windows	.118	.139
9. Evidence of Electricity	.057	.078
10. Evidence of Plumbing	.062	.083

[1] Weighting used for the Regional Housing Study (South Central Planning and Development Commission, 1975).

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Experiments with Improvement Of Yield and Fertility of Dallisgrass Seed in Louisiana

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C. R. Owen

COVER PICTURE: Graduate student in seed increase plot of Dallisgrass strain B230.

Experiments with Improvement of Yield and Fertility of Dallisgrass Seed in Louisiana

C. R. Owen*

Introduction

Dallisgrass (*Paspalum dilatatum* Poir) is a perennial warm season forage grass that is grown extensively over the Southeast. It is very palatable and makes an excellent livestock forage. Dallisgrass seed produced in the United States are usually of poor quality; therefore, most seed are imported from Australia, since Australian seed are of good quality even though they are relatively expensive.

Seed quality investigations were conducted from 1941 to 1971 to determine the primary causes of the low seed quality in Louisiana. Early results indicated that significant improvement in seed quality might be made with moderate applications of nitrogen fertilizer in early spring. Seed harvested in August were high in ergot and, consequently, low in quality. Seed produced in September and early October were of better quality than earlier seed, but yields were lower.

The purpose of these studies was to determine if additional improvements were possible by utilizing more fertile dallisgrass strains.

Literature Review

Dallisgrass is a native of South America, where it grows from southern Brazil to northern Argentina. It is thought to have been introduced into the United States around New Orleans during the latter half of the 19th century *(11)*.[1] Dallisgrass specimens were collected in Arkansas in 1879, in Texas in 1880, and in Louisiana in 1883 *(12)*. An early bulletin *(1)* from the Louisiana Agricultural Experiment Station, published in 1892, included the statement that: "The hay cut from headlands and ditch banks used to feed livestock on sugar plantations was composed of the paspalums (chiefly dilatatum), bermuda and crab grass." The common name "Dallisgrass" was derived from A. T. Dallis of LaGrange, Georgia, who was among the first to recognize its value as a pasture grass.

Ergot (*Claviceps paspali,* Stevens and Hall) appeared to be the most important factor affecting dallisgrass seed quality *(10)*. The life history of ergot in dallisgrass seed was reported by Brown *(6)*.

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[1] Italic numbers in parentheses refer to Literature Cited, page 23.

Holt and Bashaw *(9)* reported that temperature and humidity were critical at flowering for seed production. Temperatures above 90°F and relative humidity below 35 percent were adverse to seed setting. They further stated that late winter or early spring nitrogen applications increased the first seed crop yield.

Burton *(7)* compared the breeding behaviors of seed produced in South Africa, Uruguay, Australia, and the United States. He found significant differences in forage yield, anthracnose resistance, self-fertility under bags, heading dates, ergot resistance, and longevity. He concluded that the evaluation of large numbers of dallisgrass ecotypes appeared to be the breeding method most likely to lead to improvement. Owen *(10)* found considerable variation in dallisgrass, but even the most fertile lines never exceeded 50 percent seed set. Bennett, et al., *(5)* obtained interspecific hybrids ($2N = 45$ chromosomes) by crossing a yellow-anthered sexual biotype ($2N = 40$ chromosomes) as the female to a common apomictic dallisgrass ($2N = 50$ chromosomes). They reported that the first generation plants reproduced sexually. They also reported that seed set increased progressively from 40 percent to 70 percent to 80 percent for the selections in the second, third, and fourth generations, respectively.

Radiation has been used to induce changes in seed fertility. Bashaw and Hoff *(4)* irradiated common dallisgrass seed with gamma rays and neutrons and found extensive changes in growth habit and morphological characteristics not previously observed in untreated plants. Burton and Jackson *(8)* reported that asexual reproduction was not affected after exposing seed of prostrate dallisgrass to neutrons.

In 1958, Bashaw and Forbes *(2)* investigated the chromosome number and sex cell formation of four distinct dallisgrass varieties, which indicated that dallisgrass was apomictic. They reported dallisgrass to have 50 chromosomes, of which 20 were termed bivalent and 10 were termed univalent chromosomes. Further investigations reported by Bashaw and Holt *(3)* supported these results.

Materials and Methods

Experiments reported in this publication were conducted with strains isolated during the early phase of work with dallisgrass improvement and with collections of clones from natural stands. These experiments were conducted on an Olivier silt loam soil that was fertilized according to soil test recommendations.

Seed quality was determined by methods perscribed by the American Association of Official Seed Analysts. Ergot-infected florets and pure seed were separated by flotation in technical grade acetone.

Results

Breeding Behavior of Dallisgrass Strains 430 and B230

Dallisgrass strains 430 and B230 were isolated early in the breeding program *(10)*. Seed from these strains were planted in the greenhouse and later transplanted into seed increase blocks in the field. Each block contained approximately 7,000 seedlings. Seed were harvested from the seed increase blocks in early fall. Plant selections were made after the plants had recovered from seed harvesting. Selected plants were dug from the rows and each plant was separated into six clone propagules. These clones were moved to another block where they were set into rows of spaced hills. The clones from each strain were planted in separate areas. After normal cultivation the following season, mature seed heads were harvested from each clone row. They were threshed, cleaned, and analyzed for pure seed, empty florets, and ergoty florets.

Seed from clones with high, low, and intermediate pure seed content were planted into progeny rows. Seed from 24 selections of each strain were planted in spaced hills 42 inches apart in rows the same width. Seed from the parent strains were included as checks. The experimental design was a 5 x 5 triple lattice with three replications. Seed from strains 430 and B230 were planted in separate tests in adjacent blocks. When the seed had matured, they were harvested with a sickle bar mower, cut about 3 inches above the soil surface, placed into burlap bags, and dried at 138°F. The seed were cleaned, sampled, and analyzed. One harvest was made in August the first year, and three harvests were made the second year.

The seed yield and quality of individual plant selections from strains 430 and B230, and the seed quality of their progenies, are reported in Tables 1 and 2. The average pure seed content of selected plants from strains 430 and B230 was 41.3 percent and 50.7 percent, respectively. The range in percent pure seed was from 37.5 percent to 47.5 percent for selections from strain 430, and from 27.2 percent to 59 percent for strain B230's selected plants. The average empty floret content was 54.5 percent for strain 430 and 42.3 percent for strain B230 (Table 2).

Ergot content of both strains was considerably below the average of dallisgrass produced in the area. Average ergot content for seed harvested from strain 430 was only 4.1 percent. Seed of selections from strain B230 had an average ergot content of 7.5 percent.

The average pure seed content was 30 percent for progenies of strain 430, and 31.8 percent for progenies of strain B230. The empty floret content was 41.6 percent for progenies of strain 430, and 44.1 percent for progenies of strain B230. The average ergot content was 28.4 percent for progenies of strain 430, and 24.1 percent for progenies of strain B230.

The pure seed content obtained from progenies of selected plants from strains B230 and 430 from 1949 to 1951 is shown in Table 3. Pure seed

Table 1. — Seed yield and seed characteristics of selections from strain B230 and their progenies, 1950

Selection number	Yield of seed per plant parent	Yield of seed, progenies	Pure seed of parent	Empty florets of parent	Ergoty florets of parent	Pure seed of progeny	Empty florets of progeny	Ergoty florets of progeny
	Grams	Lbs./A.	Percent by weight					
Strain B230	—	146	—	—	—	30.5	47.1	22.4
1	14.0	166	52.5	46.5	1.0	33.3	43.3	23.4
2	11.7	173	47.0	51.5	1.5	29.6	46.8	23.6
3	13.2	197	57.0	42.0	1.0	33.8	45.4	20.7
4	14.8	167	59.0	40.5	0.5	34.3	42.3	23.3
5	11.9	180	54.5	44.5	1.0	32.3	44.3	23.2
6	14.7	128	56.0	42.5	1.5	33.1	44.2	23.2
7	21.2	155	27.5	49.5	23.0	15.9	34.9	49.2
8	16.1	175	37.5	43.5	19.0	24.6	33.6	41.8
9	12.0	177	52.0	30.5	16.0	30.0	45.4	24.6
10	22.2	215	51.5	48.5	0.0	31.0	47.8	21.2
11	15.5	172	47.5	52.5	0.0	29.7	40.8	26.1
12	15.5	160	53.5	37.5	9.0	30.5	45.0	24.5
13	15.2	172	48.0	44.0	8.0	30.4	48.4	21.1
14	20.1	197	48.0	48.0	4.0	34.0	43.1	22.9
15	14.0	198	50.0	49.0	1.0	33.6	48.4	18.0
16	14.4	174	58.0	41.0	1.0	33.8	47.6	18.5
17	18.1	155	49.0	42.0	9.0	32.2	45.3	22.4
18	18.7	109	57.0	42.0	1.0	32.1	44.1	23.8
19	21.8	183	50.8	34.5	14.7	34.7	43.5	21.8
20	22.0	129	48.0	41.0	11.0	32.2	42.2	25.6
21	23.6	164	47.0	40.0	13.0	34.1	46.1	19.8
22	11.6	167	54.5	33.5	12.0	32.9	47.2	19.9
23	17.0	131	58.0	34.0	8.0	36.6	41.2	22.2
24	17.5	167	54.0	38.0	8.0	34.1	46.4	19.5
Mean	16.5	166	50.7	42.3	7.5	31.8	44.1	24.1
C.V. (%)	22.5	8.0	13.7	13.7	90.0	11.3	9.0	17.0
L.S.D. (P=.05)	—	—	—	—	—	4.9	6.7	6.6

Table 2. — Seed yield and seed characteristics of selections from strain 430 and their progenies, 1950

Selection number	Yield of seed per plant parent	Yield of seed, progenies	Pure seed of parent	Empty florets of parent	Ergoty florets of parent	Pure seed of progeny	Empty florets of progeny	Ergoty florets of progeny
	Grams	Lbs./A	-----	-----	-----	Percent by weight	-----	-----
Strain 430	—	212	—	—	—	21.1	51.5	27.4
1	11.6	135	37.5	61.5	1.0	30.0	43.9	26.1
2	10.2	184	39.5	60.0	0.5	33.5	36.3	30.2
3	10.2	165	41.0	58.5	0.5	33.0	40.7	26.3
4	11.8	160	46.5	53.5	1.0	37.9	34.0	28.1
5	12.5	181	41.5	58.0	0.5	26.6	41.9	31.5
6	11.3	182	46.5	52.5	1.0	25.8	48.4	25.8
7	10.5	176	47.5	52.5	0.0	29.4	42.5	28.1
8	11.6	223	40.0	59.0	1.0	27.2	42.1	30.7
9	17.4	203	40.5	59.0	0.5	22.3	51.8	25.9
10	10.1	246	39.0	60.5	0.5	27.4	44.6	28.0
11	12.1	194	42.5	56.5	1.0	34.7	38.8	26.5
12	11.0	193	43.5	55.1	1.4	27.9	47.5	24.6
13	10.6	171	43.0	56.0	1.0	35.2	36.0	28.8
14	11.9	140	39.0	60.0	1.0	28.8	43.1	28.1
15	11.3	246	42.5	56.0	1.5	27.9	47.0	25.1
16	13.1	174	40.0	47.5	12.5	29.2	44.2	26.6
17	15.6	211	41.8	47.0	10.3	35.5	39.3	25.2
18	19.4	216	40.0	47.5	12.5	33.4	33.5	33.1
19	13.7	172	39.3	55.4	5.3	35.1	37.0	27.9
20	11.9	167	39.0	60.5	0.5	31.2	39.0	29.8
21	13.8	189	42.0	52.2	5.8	26.0	43.4	30.6
22	12.6	156	41.3	42.2	16.5	31.7	41.0	27.3
23	13.7	164	39.5	48.5	12.0	28.4	35.2	36.4
24	20.2	158	39.8	48.9	11.3	30.4	37.4	32.2
Mean	12.8	185	41.3	54.5	4.1	30.0	41.6	28.4
C. V. (%)	22.0	28.0	6.3	9.7	127.0	20.6	16.2	19.0
L.S.D. (P=.05)	—	—	—	—	—	—	—	—

Table 3. — Pure seed content of dallisgrass selections and their progenies, 1949-51

	Pure seed, percent by weight											
	Strain B230						Strain 430					
	Parent clone,	Progenies, date harvested					Parent clone,	Progenies, date harvested				
Selection number	Oct. 1949	Aug. 1950	June 1951	Aug. 1951	Oct. 1951	Avg. of progenies	Oct. 1949	Aug. 1950	June 1951	Aug. 1951	Oct. 1951	Avg. of progenies
1	52.5	33.3	21.9	11.1	24.7	22.7	37.5	30.0	15.4	11.1	11.0	16.8
2	47.0	29.6	22.5	11.9	25.1	22.3	39.5	33.5	14.1	11.9	11.9	19.2
3	57.0	33.8	18.7	13.6	24.4	22.6	41.0	33.0	15.2	13.6	10.8	17.8
4	59.0	34.8	21.4	12.4	22.2	22.7	46.5	37.9	18.1	12.4	11.1	19.9
5	54.5	32.5	25.0	12.3	22.8	23.1	41.5	26.5	13.1	12.3	10.0	15.5
6	56.0	33.1	19.5	15.5	24.3	23.1	46.5	25.8	14.1	15.5	12.4	16.9
7	27.5	15.9	11.6	9.5	14.0	12.7	47.5	29.4	12.9	9.5	10.7	15.6
8	37.5	24.5	16.0	12.7	18.6	17.9	40.0	27.2	15.7	12.7	8.7	16.1
9	52.0	30.4	21.3	15.7	21.7	22.3	40.5	22.3	18.1	15.7	10.3	16.6
10	51.5	31.0	24.6	15.3	21.2	23.0	39.0	27.3	15.5	15.3	11.4	17.5
11	47.5	33.1	20.1	8.8	23.0	21.2	42.5	34.7	15.6	8.8	10.5	17.4
12	53.5	30.5	19.4	13.3	21.2	21.1	43.5	27.5	17.5	13.3	14.9	18.3
13	48.0	30.4	16.3	15.8	24.1	21.6	43.0	35.2	17.4	15.8	11.8	20.0
14	48.0	34.0	22.1	13.1	21.2	22.6	39.0	28.8	14.5	13.1	11.1	16.9
15	50.0	33.6	22.6	12.9	24.6	23.4	42.5	27.8	16.0	12.9	8.6	16.3
16	58.0	33.8	28.4	12.8	27.7	25.7	40.0	29.2	15.2	12.8	10.2	16.8
17	49.0	32.2	24.9	11.8	18.2	21.8	41.8	35.5	15.2	11.8	12.3	18.7
18	57.0	32.1	19.9	12.9	26.0	22.7	40.0	33.4	14.3	12.9	11.5	18.0
19	50.8	35.0	21.3	14.6	22.0	23.2	39.3	35.1	16.8	14.6	9.3	18.9
20	48.0	32.2	21.3	12.6	22.6	22.2	39.0	31.2	14.6	12.6	11.5	17.5
21	47.0	33.5	22.1	10.2	26.2	23.0	42.0	26.0	15.9	10.2	9.0	15.3
22	54.5	32.9	18.1	13.8	24.7	22.4	41.3	31.7	14.2	13.8	10.5	17.5
23	58.0	36.6	18.5	17.8	25.5	24.6	39.5	28.4	15.2	17.8	15.2	19.2
24	54.0	33.8	19.9	15.1	23.2	23.0	39.8	30.4	17.6	15.1	11.0	18.5
Mean	50.7	31.8	20.6	13.3	22.8	22.1	41.4	30.3	15.4	13.1	11.1	17.5
C. V. (%)	13.7	8.8	18.7	20.9	13.3	—	6.3	9.5	14.3	20.3	20.6	—
L.S.D. (P=.05)		5.80	6.30	—	4.9	—	—	—	—	—	—	—

content for progenies of strain B230 averaged 31.8 percent in August 1950. The pure seed contents for the three harvests in 1951 were 20.6 percent in June, 13.3 percent in August, and 20.9 percent in October. Significant differences occurred among the progenies at each harvest, except in August 1951. The pure seed content for strain 430 was 30.3 percent in August 1950. The average percentages of pure seed for the three harvests were 15.4 percent in June, 13.1 percent in August, and 11.1 percent in October. There were no significant differences in percent pure seed among the progenies from strain 430.

Correlation coefficients for parent-progeny relationships of characteristics relating to seed quality are shown in Table 4. A highly significant parent-progeny correlation of r = 0.86 indicated the high percent pure seed content of strain B230 was inherited. The correlation coefficient of r = 0.069 indicated there was little relationship between seed quality of the parents and their offspring in strain 430.

Table 4. — Parent-progeny correlation coefficients for seed characteristics from selected parental plants in 1949 and seed harvested from progenies from 1950 to 1951

Seed characteristics	Strain	
	B230	430
Pure seed, percent by weight, 1949-50	.86**	.07
Empty florets, percent by weight, 1949-50	-.10	.26
Ergoty florets, percent by weight, 1949-50	.61**	.33
Pure seed, percent by weight, June 1951	.45*	.003
Pure seed, percent by weight, August 1951	.20	-.21
Pure seed, percent by weight, October 1951	.71**	.08

*Significant (P =.05).

**Highly significant (P=.01).

Seed Formation in Dallisgrass in Absence of Ergot

Several experiments have been conducted to study dallisgrass seed formation under natural environments. Under such conditions, ergot was always present in various amounts, depending on climatic conditions. This experiment was conducted to produce seed in the absence of ergot.

Seedlings from 11 lines were transplanted into soil-filled greenhouse benches in November. Fluorescent lights were suspended above the plants to furnish additional lighting for 12 hours each day. Mature seed heads were harvested March 1, April 15, and June 1. Individual seed heads were placed in separate envelopes, and later the florets from each head were separated and counted. Ergot was not observed on the dallisgrass grown in the greenhouse.

Results indicate that factors other than ergot cause low fertility in dallisgrass. A larger portion of florets from the April harvest contained seed than did those from either the March 1 or July 1 harvest, which indicated that environmental conditions within the greenhouse were more favorable for seed formation during this time (Table 5). Seed harvested July 1 developed during May and June when the air temperature in the greenhouse was abnormally high. Temperatures above 100°F were observed. Lines 2, 4, and 6 were included in the test because they previously had been found to be below average in percent pure seed. Line 2 set seed in only 1.7 percent of the florets, while line 8 filled 17.1 percent of the florets. The difference in percent seed set between these lines and line 8 may be attributed to inherent differences between these lines.

Breeding Behavior of Yellow-Anther Variant of Common Dallisgrass

A single yellow-anthered plant was found in a nursery of more than 3,000 spaced plants of dallisgrass. It occurred in a plot of strain A40. Strain A40 was moderate to low in percent seed set and moderate in seed yield. Seed were harvested from the yellow-anthered plant and planted in the greenhouse the following winter. The seedlings were transplanted to a field isolated from other dallisgrass the following spring and seed heads were harvested from each plant when mature. The seed were analyzed for purity, empty florets, and diseased florets. Nineteen plant selections were made. One purple-anthered selection from strain A40, and five purple-anthered selections from a highly fertile strain, A182, were made for comparison with the progeny from the yellow-anthered mutant.

Seed from each selection were planted in the greenhouse and the seedlings were transplanted in a field nursery in early spring. Progeny of each selection were planted in separate plots of two rows with six spaced plants in each row. Plants were 42 inches apart in rows similarly spaced. Plots were arranged in a lattice square design with three replications.

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Seed yields were low (Table 6). This may have been caused by dry weather during the time the plants were becoming established. The entries are arrayed in Table 6 in the order of their pure seed content at the August harvest. The first five progenies were from strain A182. Strain 19, a selection from strain A40 with purple anthers, ranked sixth. Strains with yellow anthers were considerably less fertile than strains with purple anthers. There were significant differences among the yellow-anthered lines for pure seed content even though they were lines of a single plant.

Table 5. — Percent seed set of dallisgrass grown in ergot-free greenhouse

Date	Line number											Avg.
	1	2	3	4	5	6	7	8	9	10	11	
March 1	7.7	2.3	14.2	4.7	12.5	2.3	8.5	12.6	12.8	16.7	5.9	9.1
Apr. 15	15.6	2.3	18.5	8.3	17.1	8.2	24.2	26.0	19.6	9.9	13.9	14.9
July 1	6.4	0.5	8.1	4.2	9.0	11.5	11.4	12.7	5.7	4.5	9.1	7.6
Average	9.9	1.7	13.6	5.7	12.9	7.3	14.7	17.1	12.7	10.4	9.6	10.5

Table 6. — Yield and seed quality of selected plants from yellow-anthered mutants of strain A40 and normal purple-anthered strain A182

			August				October			
				Seed analysis				Seed analysis		
Progeny number	Strain	Anther color	Seed yield	Pure seed	Empty florets	Ergoty florets	Seed yield	Pure seed	Empty florets	Ergoty florets
			Lbs./A.	------------------	% by wt.	------------------	Lbs./A.	------------------	% by wt.	------------------
25	A182	purple	65	26.3	36.2	37.5	49.3	42.0	21.2	36.8
22	"	purple	100	26.2	22.4	51.4	33.4	26.9	22.7	50.4
24	"	purple	98	25.1	20.3	49.6	47.3	26.5	19.6	53.9
21	"	purple	115	24.7	16.8	58.5	41.6	28.6	22.5	48.9
23	"	purple	92	22.8	18.4	58.8	47.4	25.7	21.9	52.4
19	A40	purple	105	16.7	29.7	53.6	61.0	21.8	23.8	54.4
12	"	yellow	98	9.5	25.0	65.0	54.2	24.0	27.6	48.4
10	"	yellow	87	8.3	23.2	68.5	49.9	9.9	26.8	68.3
18	"	yellow	78	7.6	20.3	72.1	47.1	11.4	26.3	62.3
20	"	yellow	76	6.7	21.6	71.7	58.4	12.0	22.1	65.9
5	"	yellow	74	5.9	23.7	70.4	48.2	8.4	26.6	65.0
4	"	yellow	81	5.7	21.5	72.8	39.1	12.7	24.9	62.4
17	"	yellow	73	4.9	19.4	75.7	46.1	9.3	27.4	63.3
3	"	yellow	83	4.8	20.7	74.5	47.1	9.1	24.4	66.5
8	"	yellow	90	4.3	24.3	71.4	42.7	9.2	24.3	66.3
15	"	yellow	98	4.3	21.5	75.2	45.6	9.9	30.5	59.6
13	"	yellow	84	4.3	22.9	72.8	39.6	7.0	24.2	68.8
11	"	yellow	82	4.3	25.4	70.3	52.1	9.0	23.1	67.9
14	"	yellow	82	4.2	21.5	74.3	39.3	8.9	27.8	63.3
1	"	yellow	99	4.0	20.9	75.1	44.3	7.6	26.2	66.2
7	"	yellow	68	3.4	25.4	71.2	43.6	7.7	26.8	65.5
16	"	yellow	64	3.2	24.6	78.2	40.8	10.0	25.6	64.4
2	"	yellow	64	3.2	21.3	75.5	31.3	8.9	23.3	69.8
9	"	yellow	61	2.9	20.9	77.2	37.1	5.6	21.3	73.1
6	"	yellow	88	2.9	23.0	74.1	33.3	7.6	26.5	65.9
Mean			84	9.5	23.1	67.4	44.0	14.2	24.9	60.9
C. V. (%)			20.5	10.0	21.0	9.3	25.9	6.0	6.8	3.1
L.S.D. (P=.05)			10.0	0.33	3.8	4.1	6.6	1.4	3.4	3.0

Progeny 25 had less ergot and exceeded the other purple-anthered progenies for percent pure seed.

Percent pure seed ranged from 5.6 percent for progeny 9 to 42 percent for progeny 25 for the October harvest. The data illustrated the variability for seed yield and quality present in dallisgrass, and also showed the seed production limitations of dallisgrass due to the low percentage of pure seed obtained from even the best lines.

The data in Table 7 indicated a difference in seed yield as well as in seed quality among strains. Data from strain A40 were taken from the yellow-anthered mutant in 1944 and 1945. There was considerable year-to-year fluctuation in percent pure seed of these strains. These data were taken from space-planted nurseries, and samples for analysis were taken from seed that were harvested and threshed by hand and included all mature florets on plants at harvest time.

Effects of Radiation on Dallisgrass

Seed samples (0.75 g) from dallisgrass strains B230, 430, and 625 were sent to the University of Tennessee, Atomic Energy Commission, Agricultural Research Laboratories for treatment. The treatments were 2 and 3 hours exposure to a radiation source producing radiation levels of 1.4×10^{12} thermal N/cm^2/hr. and 7.9×10^{10} fast N/cm^2/hr.

Strains B230, 430, and 625 were selections from common dallisgrass that had excelled in fertility and had been somewhat superior for forage production. They had some resistance to certain foliar diseases, but otherwise they did not have any specific characteristic that would distinguish them from other dallisgrass plants. They were irradiated to determine the effects on the fertility of each strain. Progeny tests were made on the R_2 and R_3 generations from strain 625 to determine if changes observed in the R_1 generation were inherited.

Irradiated seed of three strains were planted in the greenhouse and later the seedlings were transplanted into spaced hills in the field. Untreated seed of each strain were planted as checks. The experimental design was a randomized complete block with four replications. Each plot was 10 hills long by five rows wide, except the check plots which were only two rows wide. When the seed were mature, each plant was cut about 2 inches above the soil surface and placed in a separate bag. The plants were dried, weighed, and the seed were threshed from each plant. The seed from plants were analyzed for pure seed, empty florets, and ergoty florets. Tukey's test was used for making comparisons of radiation effects on the strains *(13)*.

Seed produced on plants that grew from irradiated seed had significantly less pure seed than did that produced on plants from untreated seed (Table 8). Plants from seed exposed for 3 hours were significantly less fertile than plants from seed exposed for 2 hours at the same dosage level. The differences in radiation effects on fertility of R_1 plants from the three strains

Table 7. — Yield and seed quality of strain A40 as compared with strain A182 for the August harvests from 1942 to 1945

Year	Strain A182				Strain A40			
	Seed yield	Empty florets	Pure seed	Ergotized florets	Seed yield	Empty florets	Pure seed	Ergotized florets
	Lbs./A.	------------------------% by wt.	------------------------		Lbs./A.	------------------------% by wt.	------------------------	
1942	154.6	23.4	42.0	34.6	117.5	29.6	14.9	55.5
1943	89.6	40.3	29.7	30.0	82.2	25.0	26.7	48.3
1944	285.0	10.9	15.6	73.5	202.2	16.0	8.0	76.0*
1945	179.6	31.0	51.0	18.0	93.5	43.5	24.5	32.0*
Mean	76.6	26.6	34.5	38.9	123.8	27.1	18.7	54.2

*A40 yellow-anther mutant.

Table 8. — Frequency distribution for percent pure seed from plants grown from irradiated seed

	Frequency distribution for % pure seed					
Strain	0-10	11-20	21-30	31-40	41-50	Average % pure seed
			Untreated check			
625	3a[1]	3a	10a	22a	38a	37.9
B230	1a	11a	14a	38a	26a	36.5
430	3a	10a	19a	34a	14a	32.0
			Radiation exposure, 2 hours			
625	32b	42a	71b	43a	12a	18.3
B230	66a	40a	44ab	25ab	10a	18.8
430	95a	59a	32a	9b	2a	13.0
			Radiation exposure, 3 hours			
625	92a	44a	40a	17a	5a	14.9
B230	113a	47a	17ab	8a	3a	10.6
430	154b	27a	2b	6a	0a	6.7

[1] Within treatments, values within a column with a letter in common do not differ at the .05 level using Tukey's test.

were highly significant. Strain 430 was more severely affected by radiation than strains B230 or 625. Seed irradiated for 2 hours produced plants with about one-half the pure seed content of untreated seed. Irradiated seed of strain 625 produced significantly fewer plants with 1 percent or less pure seed than strains B230 or 430. Strain 625 also had significantly more plants producing 21 percent to 30 percent pure seed. Strain 430 had significantly fewer plants producing 31 percent to 40 percent pure seed.

Strain 430 was more severely affected with the 3-hour exposure time. The average pure seed content for untreated seed was 36.5 percent for strain B230, 32 percent for strain 430, and 37.9 percent for strain 625. Seed irradiated for 2 hours produced plants with an average pure seed content of 18.8 percent for strain B230, 13 percent for strain 430, and 18.3 percent for strain 625. Seed of strain B230 receiving 3 hours exposure to neutrons produced plants that had 10.6 percent pure seed. Treated seed from strain 430 produced plants that averaged 6.7 percent pure seed. Seed of strain 625 produced plants with a pure seed content of 14.9 percent. This indicated that strain 430 was more severely affected by the radiation treatment, suggesting the possibility of genetically controlled differential response to radiation among these strains.

The dry weight of each plant was obtained and recorded before the seed were threshed. Dry weights of the plants were arrayed in frequency classes of 20-gram intervals, ranging from 0-20 grams to 161-180 grams (Table 9). Tukey's test was used for making comparisons. Comparisons of frequency classes for dry weight of the plants did not show a differential response to radiation among the strains, as was evident in the comparisons with pure

Table 9. — Frequency distribution for plant dry weight from seed irradiated with neutrons

Strain	Frequency distribution (dry weight of plants in grams)									
	0-20	21-40	41-60	61-80	81-100	101-120	121-140	141-160	161-180	Avg. wt.
Untreated check										
625	2a[1]	4a	12a	23a	17a	11a	6a	5a	0a	81.1
B230	0a	1a	11a	21a	23a	14a	3a	5a	2a	88.0
430	4a	4a	9a	24a	16a	13a	7a	2a	0a	80.7
Radiation exposure, 2 hours										
625	3a	26a	55a	52a	36a	17a	15a	5a	0a	72.5
B230	14a	14a	46a	59a	40a	13a	4a	1a	1a	57.9
430	8a	29a	50a	57a	20a	6a	3a	0a	0a	64.3
Radiation exposure, 3 hours										
625	9b	36a	66a	45a	25a	11a	4a	0a	0a	60.7
B230	41a	37a	44a	35a	20a	7a	5a	0a	0a	49.4
430	29ab	29a	50a	55a	20a	6a	3a	0a	0a	54.7

[1] Within treatments, values within a column with a letter in common do not differ at the .05 level using Tukey's test.

seed content. Irradiation of the seed caused a significant decrease in the vigor of R_1 plants. Its effect was similar for each strain; however, strain 625 had significantly fewer plants in the class of plants weighing 20 grams or less than did strains B230 or 430 with the 3-hour treatment.

Mutations for anther color were observed among plants from irradiated seed. Normal plants had purple anthers. All strains showed more anther color mutations with the 3-hour exposure (Table 10).

Progeny tests were conducted with plants selected from strain 625 to determine if changes in pure seed content were heritable. Although not of large magnitude, the correlation coefficients were highly significant and show that changes expressed in the R_1 plants were inherited and likely would become permanent characteristics which would be passed to later generations of each line (Table 11).

Table 10. — Anther color mutations observed in R_1 plants

Strain	Exposure treatment: Check	2 hours	3 hours	Total no. mutations
	--------------No. anther color mutations		-------------	
B230	0	4	15	19
430	0	7	8	15
625	0	3	6	9
L.S.D. (P=.05)	—	1.4	1.4	—

Table 11. — Parent-progeny correlation coefficients for pure seed content of selected plants from irradiated seed of dallisgrass strain 625

Characters	No. of plants	Correlation coefficient
R_1 parents, R_2 progenies	49	0.54**
R_2 parents, R_3 progenies	100	0.43**

**Highly significant at the .01 level of probability.

Performance of Dallisgrass Collected in Louisiana and South Arkansas

Dallisgrass collections were made from natural stands in north Louisiana and south Arkansas to sample ecotypes in these areas. It was thought that plants from these areas might be more resistant to freezing as well as more fertile than those collected in south Louisiana.

The collections were made in early spring. Approximately 50 plants were selected at random from each location. The sampling began in Caddo Parish north of Shreveport and continued into south Arkansas. From there the survey extended across south Arkansas to the Mississippi River and then to Natchez, Mississippi. Collections were made at 13 different locations. The vegetative propagules were kept alive by placing them in moist peat moss. The propagules were transplanted into spaced hills at Baton Rouge. Plant propagules of strain 625 were planted in the nursery as a check. When seed heads matured, they were harvested from each plant separately, threshed, cleaned, and analyzed.

Seed fertility studies with this collection are summarized in Table 12. The average percent pure seed for the collection was 12.1 percent. The pure seed content of plants from strain 625 was lower than normal but still exceeded the average of the nursery. In spite of the low pure seed content, there was considerable variation among the plants. However, none of the plants was superior to strain 625. The percent pure seed during the second season was slightly higher than the first year. Strain 625 produced 20.5 percent pure seed as compared with the average of the nursery of 15.8 percent. Most of the plants collected were more variable for pure seed content than plants from strain 625.

Dallisgrass plants collected from old established stands in north Louisiana and south Arkansas appeared to be more susceptible to foliar diseases and tended to have less growth during late summer and fall than strains isolated in south Louisiana. None of the plants collected was more fertile than strain 625; however, individual selections were found that equaled strain 625 for pure seed content.

A variant type was found among the plants collected from north Louisiana that was unusually hirsute, with longer and more numerous hairs than normal plants on the leaves, stems, and seed. It was the only specimen reported from dallisgrass that showed a distinct gross morphological difference from normal plants. Aside from the hair covering on the leaves and glumes, it apparently was not different from other plants. Progeny of this plant were uniform for hirsuteness, fertility was about average, and ergot infection was normal. Cytological investigations by E. C. Bashaw, Texas Agricultural Experiment Station, showed that the reproductive behavior of this strain was like that of normal dallisgrass. The hirsute character apparently resulted from a mutation.

Evaluation of Dallisgrass Collected from South Louisiana

Dallisgrass collections were made in south Louisiana in 1965 and 1970. The purpose of these collections was to identify fertile clones and determine if their progeny were uniform or if they showed segregation for vegetative and seed quality characters. Segregating progeny would be an indication of sexual reproduction in dallisgrass. Sexual reproduction would be useful to a dallisgrass breeding program since it would provide a source of variation and allow for hybridization.

Seed and vegetative characters of the plants collected in 1965 and the

Table 12. — Pure seed content of dallisgrass collections from natural stands in north Louisiana and south Arkansas transplanted to the Perkins Road Farm at Baton Rouge

		Mean % pure seed		Range in percent pure seed				Coefficient of variation (%)	
				First year		Second year			
Source of clones	No. of clones	First year	Second year	High	Low	High	Low	First year	Second year
1 Strain 625	34	17.9	20.5	26.0	5.0	34.0	3.5	23.4	25.8
2 Northwest Louisiana	31	12.2	13.6	16.0	7.0	23.5	5.0	26.2	32.7
3 Northwest Louisiana	35	10.7	14.9	16.0	6.5	26.5	7.7	23.5	27.5
4 Southwest Arkansas	30	9.9	11.5	16.0	6.0	19.5	5.0	28.0	38.3
5 Southwest Arkansas	31	11.0	13.2	18.0	5.0	20.0	2.0	89.3	31.3
6 South Arkansas	33	12.1	14.7	22.5	6.0	27.5	1.0	30.6	33.4
7 Southeast Arkansas	35	12.5	15.9	21.0	6.0	27.0	6.0	23.5	28.5
8 Southeast Arkansas	32	14.7	18.3	23.5	5.0	27.5	4.5	17.3	29.3
9 Southeast Arkansas	35	12.8	18.5	22.5	5.1	28.5	7.0	33.6	26.2
10 Northeast Louisiana	35	13.5	14.1	23.0	8.0	23.0	3.7	28.0	33.3
11 Northeast Louisiana	32	10.3	15.5	16.5	7.0	27.0	7.0	24.1	34.5
12 Northeast Louisiana	34	10.6	18.4	14.0	5.0	26.5	7.5	26.2	22.5
13 Northeast Louisiana	34	10.4	15.1	16.0	4.7	25.0	8.0	32.5	36.1
14 East Mississippi	33	10.2	17.2	15.5	5.0	27.5	9.0	27.9	34.0
Avg.		12.1	15.8	19.0	5.4	25.9	5.5		

progeny of the more fertile clones were observed in space-planted progeny rows. The progeny were not variable and there was no indication of sexuality or genetic segregation. In 1970, propagules were taken from 50 plants from 23 locations between Baton Rouge and LaPlace. The propagules were transplanted in 4-ounce peat pots and allowed to establish roots in the greenhouse before being transferred to the field in plots two rows wide by six hills long. The plots were randomized into a lattice square design with four replications. Strains B230 and 625 were used as check strains. One seed harvest was made in 1970 and a second harvest was made in 1971. The seed heads were cut from each plant, placed in separate bags, and the seed were threshed, cleaned, and analyzed in the laboratory.

The average percent pure seed for 1970 was 8.1 percent (Table 13). The highest percent pure seed content was 16 percent. The average pure seed content for all collections in 1971 was 16.5 percent and the high entry was

Table 13. — Average seed quality of dallisgrass collected from 23 locations south of Baton Rouge

	1970			1971		
Entry No.	Pure seed	Ergot	Empty Florets	Pure seed	Ergot	Empty Florets
	Percent					
25(625)	16.0	10.2	73.8	24.3	29.3	46.4
24(B230)	14.1	10.3	75.6	20.1	33.2	46.7
15	10.5	15.8	73.7	18.4	29.7	51.9
6	10.1	18.3	71.6	18.1	29.2	52.7
9	9.1	19.4	71.5	16.1	39.9	44.0
1	8.8	15.2	76.0	18.8	29.6	51.6
17	8.7	15.6	75.7	15.1	33.8	51.1
23	8.6	14.6	76.8	19.7	32.1	48.2
13	8.6	17.9	73.5	16.1	35.2	48.7
18	8.2	16.0	75.8	15.5	38.1	46.4
20	8.2	15.4	76.4	14.9	37.4	47.7
10	7.5	18.1	74.4	14.7	35.9	49.4
16	7.5	15.2	77.3	21.6	35.6	42.8
7	7.5	19.1	73.4	17.0	33.8	49.2
12	7.2	18.6	74.2	13.6	35.1	51.3
5	7.0	16.7	76.3	18.1	27.4	54.5
2	6.9	15.2	77.9	13.9	34.6	51.5
4	6.5	14.7	78.8	16.4	29.2	54.4
11	6.3	16.0	77.7	15.0	38.1	46.9
8	6.3	14.6	79.1	16.0	37.1	46.9
22	6.3	15.2	78.5	13.7	39.4	46.9
3	6.0	19.3	74.7	15.7	41.2	43.1
19	5.9	15.8	78.3	14.7	39.4	45.9
14	5.7	19.1	75.2	13.0	36.9	50.1
21	5.6	15.9	78.5	12.7	34.9	52.4
Mean	8.1	15.9	76.0	16.5	34.7	48.8
L.S.D. (P=.05)	2.6	—	—	5.5	—	—

strain 625 with 24.3 percent pure seed. The difference between the sources for pure seed content was significant. The differences among the sources for ergot-infected seed were not significant for either year.

Dallisgrass Seed Production

Imports of dallisgrass seed from Australia have been the main source of high-quality planting seed for the Southeast. The amount of dallisgrass seed imported since 1921 is shown in Table 14. The amount of dallisgrass seed produced in the United States has been negligible. Seed of this grass have been harvested from pastures, but most of it was sold locally and no records are available regarding the amount or quality of this seed.

Dallisgrass seed production in Louisiana is subject to many hazards. Prolonged droughts during seed formation lowers seed quality. Excessive rainfall after the seed are mature causes the seed to shatter.

Other hazards to seed production are weeds. Weeds causing the most problems are johnsongrass *(Sorghum halapense* L.), vaseygrass (*Paspalum urvillei* Steud.), barnyardgrass (*Echinochloa crusgalli* L.), *Bacharia* spp., and goosegrass (*Eleucine indica* L.). The seed of these grasses mix with dallisgrass seed and are difficult to separate with cleaning equipment.

The seed increase fields established on the Perkins Road Farm near Baton Rouge were planted in standard width rows and the middles were

Table 14. — Dallisgrass seed imports, 1921 to 1975[1]

Year	Pounds	Year	Pounds	Year	Pounds
1920-21	11,600	1938-39	106,400	1956-57	927,000
1921-22	9,500	1939-40	313,400	1957-58	403,000
1922-23	6,300	1940-41	729,200	1958-59	1,350,000
1923-24	29,400	1941-42	258,800	1959-60	250,000
1924-25	1,000	1942-43	653,500	1960-61	272,000
1925-26	1,000	1943-44	566,100	1961-62	598,000
1926-27	15,600	1944-45	249,100	1962-63	728,000
1927-28	12,400	1945-46	575,400	1963-64	167,000
1928-29	26,000	1946-47	1,185,200	1964-65	161,000
1929-30	37,500	1947-48	1,701,100	1965-66	121,000
1930-31	19,400	1948-49	997,600	1966-67	223,000
1931-32	18,200	1949-50	727,000	1967-68	160,000
1932-33	6,300	1950-51	1,256,000	1968-69	125,000
1933-34	42,300	1951-52	500,000	1969-70	159,000
1934-35	28,500	1952-53	655,000	1970-71	288,000
1935-36	71,500	1953-54	419,000	1971-72	195,000
1936-37	108,100	1954-55	1,480,000	1972-73	50,000
1937-38	144,300	1955-56	611,000	1973-74	49,700
				1974-75	109,900[2]

[1] Source: United States Department of Agriculture Yearbooks, Statistical Sections.

[2] Imports for the first 6 months of 1974-1975.

cultivated two or three times the first growing season to keep down weed competition. When weeds were a problem in the drill rows, the fields were mowed. With these practices it was possible to keep weeds under control until the dallisgrass was established. The rows were planted on a prepared seedbed adequately fertilized with phosphorus and potash, but with no nitrogen applied until the seedlings became established. The seeding rate was 3 to 5 pounds of pure live seed per acre. The dallisgrass responded readily to nitrogen fertilizer, and 30 to 50 pounds per acre seemed adequate for seed production. Higher rates produced excess forage, delayed seed formation, and created problems with the harvesting operation.

Summary

Several dallisgrass strains were considerably more fertile than common dallisgrass. The superior lines included strains A182, B230, 430, and 625.

Strains with low fertility usually produced progeny with low fertility, and strains with above average fertility tended to produce progeny with better than average fertility. Even the best strains seldom produced seed with a pure seed content of more than 30 percent.

Severe ergot infection often occurred in dallisgrass in July and August in Louisiana and apparently reduced seed set. However, ergot honeydew tended to prevent seed from shattering and may have helped increase harvestable seed yields.

Three dallisgrass strains were irradiated with neutrons; however, no superior mutants were obtained as a result.

The production of dallisgrass seed in Louisiana was very much affected by weather conditions. However, the more fertile strains produced up to 200 pounds of dallisgrass seed per acre with about 25 percent pure seed by weight. This indicated that it may be economically feasible to produce dallisgrass seed in Louisiana.

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Economic Implications of Producing Beef Calves with Four Pasture Management Systems

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AGRICULTURAL EXPERIMENT STATION
DOYLE CHAMBERS, DIRECTOR

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The Louisiana Agricultural Experiment Station follows a nondiscriminatory policy in programs and employment.

Economic Implications of Producing Beef Calves with Four Pasture Management Systems

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Introduction

Beef cattle have provided a major part of the gross agricultural income in Louisiana for a number of years. Demand by Western and Midwestern feedlots for feeder cattle produced in Louisiana has emphasized the potential of the state's beef industry. Increased consumption of high-protein foods in the United States suggests that the Louisiana beef producer is in a very favorable position, since beef is a high-protein food that can be produced mainly from forages.

In areas of high forage-production potential, such as Louisiana, profitable cow-calf operations make efficient use of forage produced. Efficient livestock and high-quality pastures must be used for greatest returns. Climatic conditions in most parts of the Southeast will not presently permit forage to be grazed continuously for 12 months without supplementation of protein and/or energy.

A beef cattle project was initiated at the West Louisiana Experiment Station, Rosepine, on December 1, 1971. Four groups of cow-calf units were used to graze different forage combinations. An annual comparison was made of total beef production, reproductive performance, and costs and returns from fall- and spring-dropped calves. Results of the 4-year study are presented in this publication.

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Experimental Procedure

General Management of Pastures

This experiment involved use of 120 acres in a year-round pasture management system for cow-calf herds. Soil types were predominantly Angie and Bowie fine sandy loam. Each management system consisted of 30 acres.

The experimental area was limed with 2 tons of dolomitic limestone per acre at the beginning of the test and the average pH of the soil remained above 6.0 throughout the study. All pastures were fertilized at the same rate. The average annual fertilization for the 4-year period was 225 pounds of N, 96 pounds of P_2O_5, and 96 pounds of K_2O per acre. Half of the fertilizer was applied in the fall and half in the spring.

Bermudagrass pastures were sodseeded in the fall with a combination of 20 pounds of ryegrass, 15 pounds of common crimson clover, and 3 pounds of Louisiana S-1 white clover per acre.

Temporary winter and summer pastures were seeded on a prepared seedbed. Temporary winter pastures were seeded in late September with a mixture of wheat, rye, and ryegrass at rates of 30, 30, and 25 pounds per acre, respectively. These same pastures were seeded with millet at the rate of 30 pounds per acre on approximately May 1 each year. The 120-acre pasture plan is shown in Table 1.

Specific Systems

Pasture System I — Pasture System I consisted of three 10-acre fields (20 acres of common bermudagrass and 10 acres of Coastal bermudagrass) overseeded in September with ryegrass and S-1 white clover. No prepared seedbeds were used. Of the four systems used in the study, System I represented the smallest expenditure for seed and land preparation.

Pasture System II — Pasture System II consisted of 15 acres of common bermudagrass, 10 acres of Coastal bermudagrass, and 5 acres for creep grazing of calves. Creep-grazing acreage was seeded on a prepared seedbed in both summer and winter. This system represented a larger expenditure for seed and land preparation, and less grazing area for the cow herd, than did System I.

Pasture System III — Ten acres each of common and Coastal bermudagrass and 10 acres of summer and winter annuals seeded on a prepared seedbed provided the forage for the cow herd in System III. This system was designed to provide high-quality forage for the cattle, but also required greater investment than Systems I and II. No creep grazing was provided for calves in System III.

Pasture System IV — This system was the most expensive of the four and was designed to provide high-quality forage for the cow herd and 5 acres of creep grazing for the calves. Ten acres of winter and summer

Table 1. — Diagram of acreage and crop layout by pasture system

System I

Coastal bermuda overseeded Ryegrass-crimson and white clover (10 acres)	Common bermuda overseeded Ryegrass-crimson and white clover (10 acres)	Common bermuda overseeded Ryegrass-crimson and white clover (10 acres)

System II

Coastal bermuda overseeded Ryegrass-crimson and white clover (10 acres)	Common bermuda overseeded Ryegrass-crimson and white clover (5 acres) --------------------- Wheat-rye-ryegrass followed by millet (5 acres)	Common bermuda overseeded Ryegrass-crimson and white clover (10 acres)

System III

Coastal bermuda overseeded Ryegrass-crimson and white clover (10 acres)	Wheat-rye-ryegrass followed by millet (10 acres)	Common bermuda overseeded Ryegrass-crimson and white clover (10 acres)

System IV

Wheat-rye-ryegrass followed by millet (10 acres)	Common bermuda overseeded Ryegrass-crimson and white clover (5 acres) --------------------- Wheat-rye-ryegrass followed by millet (5 acres)	Coastal bermuda overseeded Ryegrass-crimson and white clover (10 acres)

annuals seeded on a prepared seedbed, plus 15 acres of common bermudagrass, provided forage for the cows. In addition, the calves had access to a creep-grazing area of temporary forages planted on a prepared seedbed.

Comparing the systems, expenditures for forage production increased from System I through System IV. No temporary forages planted on prepared seedbeds were used in System I, and the greatest quantity of this forage was used in System IV. System III and IV provided grazing for the herd on forages produced on prepared seedbeds (Table 1).

Management of Cattle

Four groups of cows and calves were placed on pasture December 1, 1971. Each group consisted of two bulls (one Angus and one Hereford), 25 cows, and four replacement heifers. Bulls of different breeds were used so that calf sires could be identified. Fifteen cows either had a calf by side or were diagnosed as pregnant to calve by December 31, 1971. Ten cows were diagnosed as pregnant to calve between January 1 and March 31, 1972. Breeding season was from December 1 through July 31.

Bulls were rotated within groups on a weekly basis for the first 6 weeks, then every 2 weeks for the remainder of the breeding season. The bulls were rotated yearly among herds, allowing each bull pair to be used in each herd for one breeding season during the 4 years.

Each group was restructured on December 1 from 1972 through 1975. Four replacement heifers were placed in each breeding group from within that breeding group, if they were available. Where sufficient numbers were not available, comparable heifers were used. Cows in each group that had not calved by November were palpated and open cows were replaced with pregnant heifers from within the group. Cows were culled for physical defects such as disease, age, or injury. Cows that lost calves at birth were replaced immediately with comparable "dummy" cows and calves, which were used to measure the carrying capacity of the pasture but did not enter into reproductive evaluations. These cows were replaced with pregnant heifers from within the group, if available; if heifers were not available, the cows were left in the group. Cows were weighed December 1, April 1, June 1, and when calves were weaned. Calves were weighed at birth, at 210 days of age, and at weaning. Calves were weaned on June 1, August 1,.October 1, or December 1.

Analytical Methods

Collected data were analyzed for real differences among the four pasture-management systems based on the least squares analysis of variance. Cost-and-return analyses were based on average inputs. Performance rates were based on means from the statistical analysis. Prices for inputs and beef cattle were based on averages for Louisiana during the period of the study.

Results and Discussion

Feed and Hay Production and Consumption

The results of feed consumption and hay production during the study are shown in Table 2. In System I, which had no temporary grazing, more hay and protein were fed for a greater number of days than in the other systems. More tons of hay were also produced in System I than in other systems. In System IV, which contained the largest number of acres of temporary

Table 2. — Feed consumption and hay production, 4-year average

Pasture system	Number of mature animals	Days on pasture		Hay and protein fed (days)	Hay harvested (tons)	Hay fed (tons)	Protein 1973 37% (lb.)	Supplement 1974-76 molasses-urea (lb.)
		Winter	Summer					
I	30	170	195	94	39.6	24.1	6,733	2,624
II	30	175	190	93	35.5	21.7	5,000	2,416
III	30	169	196	92	31.1	21.9	4,633	2,740
IV	30	163	202	80	20.2	20.9	6,300	2,476

pasture, the winter feeding period was shorter and less hay was fed than in the other systems. The smallest amount of hay (20.2 tons) was produced in System IV.

Performance Data

Reproductive performance and average calving interval for the 4 years of the study are shown in Tables 5 and 6. An attempt was made to breed 463 cows and, of these, 390 — 84 percent — weaned calves. Of the 463 cows exposed during the 4 years, 431 calved or were pregnant when palpated each year. The 93.1 percent conception rate permitted selecting 25 pregnant cows each year for each herd. The average calf crop weaned as a percentage of cows pregnant was 90.5 percent. Vibriosis was diagnosed in the cows in System I in 1972. This probably accounts for this system having the largest number of open cows and the smallest number of calves weaned during the 4-year test. There were no significant differences among systems in reproductive performance as measured by calving interval, percent calf crop, and percent cows diagnosed as pregnant.

Pasture System I — The average adjusted 210-day weights and actual weaning weights of calves in System I were 359 and 414 pounds, respectively (Table 3). In this system, where no creep grazing and no annuals planted on prepared seedbeds were used, calves born in the spring had significantly heavier 210-day adjusted weights than those born in the fall (396 *vs.* 322 pounds). Actual weaning weights were not significantly different when spring and fall calves were compared (421 *vs.* 407 pounds). More hay was harvested (39 tons) and more hay was fed (24 tons) in System I than in any other system.

Table 3. — Average 210-day adjusted and weaning weights of all calves in various pasture management systems, 1972-76

Pasture system[1]	Calving season	No. of calves	Adjusted 210-day wt.	Weaning wt.
			Pounds	Pounds
I	Fall	64	322.2[a]	407.4[a]
I	Spring	29	396.7[b]	421.8[a]
II	Fall	69	414.6[c]	498.6[c]
II	Spring	29	423.4[c]	446.9[d]
III	Fall	74	361.0[e]	442.5[e]
III	Spring	23	439.2[f]	468.6[e]
IV	Fall	65	387.6[g]	465.8[g]
IV	Spring	31	398.9[g]	415.6[h]

[1] I = 30 acres of bermudagrass overseeded to winter annuals; II = 25 acres of bermuda overseeded to winter annuals, plus a 5-acre creep seeded to winter and summer annuals; III = 20 acres of bermuda overseeded to winter annuals, plus 10 acres seeded to winter and summer annuals; IV = 15 acres of bermuda overseeded to winter annuals, plus 10 acres seeded to winter and summer annuals, plus a 5-acre creep seeded to winter and summer annuals.

[a b c d e f g] Means in same column for a given system with same superscript are not different at the 5% level.

Pasture System II — The adjusted 210-day weights for fall- and spring-born calves were not significantly different (415 *vs.* 423 pounds) in System II, where a creep-grazing area was used. When fall calves in System II were compared with fall calves in System I, the addition of creep grazing resulted in significantly heavier fall-born calves both at 210 days (415 *vs.* 322 pounds) and at weaning (498 *vs.* 407 pounds). Fall calves weighed significantly more at weaning than spring calves in System II (498 *vs.* 446 pounds). The average 210-day adjusted and actual weaning weights for all calves in this system were 419 and 472 pounds, respectively. Thirty-five tons of hay were harvested and 21 tons were fed to the cows during the winter.

Pasture System III — Pasture System III, where 10 acres of winter and summer annuals planted on prepared seedbeds were used with no creep grazing for the calves, produced spring calves that were significantly heavier at 210 days (439 *vs.* 361 pounds) and slightly heavier at weaning (468 *vs.* 442 pounds) than calves born in the fall. The average adjusted 210-day and actual weaning weights for all calves in System III were 400 and 455 pounds, respectively. Twenty-one tons of hay were fed to the cows in this system and 31 tons were harvested.

Pasture System IV — The overall adjusted 210-day and actual weaning weights in this system were 393 and 440 pounds, respectively. The adjusted 210-day weights of calves born in the fall were not significantly different from the weights of spring calves (387 *vs.* 398 pounds). Fall calves weighed significantly more at weaning than the calves born in the spring (465 *vs.* 415 pounds). Only 20 tons of hay were produced in System IV, and that same amount was fed to the cows during the wintering period. A more detailed summary of performance within each system is presented in Table 4.

Effect of Management on Weaning Weights

The pasture management systems had a significant effect on both average adjusted 210-day weight and average weaning weight of all calves born, regardless of season. Pasture System II (with a creep-grazing area for the calves) produced calves with the heaviest weights (473 pounds), as shown in Table 3. The lowest weights resulted from Pasture System I. Using 10 acres of prepared seedbed pasture (ryegrass and millet) as part of the 30 acres for cow herds in Systems III and IV improved calf weaning weights compared with weaning weights in System I, but the weights were lower than those obtained with System II. Creep grazing in System IV only slightly improved 210-day and weaning weights of fall calves compared with the same system (III) without creep grazing. Creep grazing did not improve weights of spring calves. Apparently, the 25 acres of bermudagrass pasture overseeded in winter and 5 acres of creep grazing were a

Table 4. — Average weights of fall and spring calves produced from various pasture management systems

Pasture system[1]	Calving season	Sex	Adjusted 210-day wt.	Actual weaning wt.
			Pounds	
I	Fall	Male	335.6	430.5
I	Spring	Male	397.4	426.1
I	Fall	Female	308.9	384.4
I	Spring	Female	395.0	417.5
II	Fall	Male	426.5	513.2
II	Spring	Male	442.5	467.4
II	Fall	Female	402.6	484.0
II	Spring	Female	404.3	426.4
III	Fall	Male	381.1	465.9
III	Spring	Male	433.3	470.0
III	Fall	Female	341.0	419.1
III	Spring	Female	445.2	467.3
IV	Fall	Male	400.0	485.0
IV	Spring	Male	418.3	430.2
IV	Fall	Female	375.4	446.8
IV	Spring	Female	379.6	400.9

[1] I = 30 acres of bermudagrass overseeded to winter annuals; II = 25 acres of bermuda overseeded to winter annuals, plus a 5-acre creep seeded to annuals; III = 20 acres of bermuda overseeded to winter annuals, plus 10 acres seeded to winter and summer annuals; IV = 15 acres of bermuda overseeded to winter annuals, plus 10 acres seeded to winter and summer annuals, plus a 5-acre creep seeded to winter and summer annuals.

combination that gave a better balance of forage for both the cows and their calves.

Calves born from January through March (spring) had heavier average 210-day adjusted weights than calves born from October through December (fall). These heavier adjusted weights no doubt were the result of the availability of high-quality forage during the early part of the lactation period of cows calving in the spring. The difference in 210-day adjusted weights between fall and spring calves not receiving creep grazing was 75 pounds, while the difference between fall and spring calves receiving creep grazing was 10 pounds. This clearly demonstrates the value of creep grazing for the fall-born calf whose dam is supported mostly on hay and protein supplement during the first months of lactation (October-December).

Adjusted 210-day weights indicate that fall calves made better use of the creep grazing, probably because they were older when grazing ryegrass creep in the spring and when grazing millet in summer. Summer creep grazing of millet gave an advantage to spring-born calves in System II compared with calves in System I, but spring-born calves in System IV with creep grazing of millet were lighter than spring-born calves produced

Table 5. — Results of reproductive performance, 1972-76

Pasture system	Type animal	Attempted to breed	Bred or calved following fall	Open	Calves dropped	Calves weaned
I	Cows	100	89	11[1]	85	79
	Heifers	16	15	0	14	14
II	Cows	100	94	4	92	86
	Heifers	16	16	0	16	15
III	Cows	100	96	1	94	86
	Heifers	16	15	1	15	15
IV	Cows	100	91	5	90	83
	Heifers	15	15	0	14	12
Total		463	431			390

[1] Of the 11 open cows, five were open during the first year of the study when vibriosis was diagnosed in the herd.

Table 6. — Average calving interval for cows that remained in herds 4 years

Pasture system	Number of cows	Calving interval[1] (days)
I	13	366
II	12	353
III	14	351
IV	15	363

[1] Differences not statistically significant at 5% level.

in System III with no creep. Calves spent very little time in millet creep areas, but spent considerable time in ryegrass-wheat areas, indicating the millet was less palatable.

Although slightly lighter at 210-day adjusted weights, fall-born calves in Systems II and IV (both with 5 acres of creep grazing) were 52 and 50 pounds heavier, respectively, at weaning than calves born in the spring in the same systems. Fall calves made much better use of the ryegrass-wheat creep than the spring calves made of the millet creep. In Systems I and III (no creep grazing), spring calves averaged about 70 pounds heavier than fall calves at 210-day adjusted weights, but were only 14 pounds and 26 pounds heavier (not significant), respectively, at weaning. Fall calves had better quality forage from 6 to 9 months of age than spring calves that reached weaning age between October and December. All fall-born calves increased in weight by approximately 80 pounds from 210 days to weaning, regardless of the system. Therefore, creep grazing had no effect during this time.

Costs and Returns

For comparing returns among systems, the following information was used for the 4-year period: (1) average percent calf crop — 90 percent — for all groups; (2) the average ratio of spring and fall calves, which was 29 percent and 71 percent, respectively; (3) four replacement heifers selected from the fall heifers for each group; (4) average weaning weight by sex, season, and group, and (5) average price by sex and month of weaning. Spring calves were weaned in October and December; fall calves were weaned in June and August. For the analysis, fractional parts of animals resulting from use of percentages were rounded to whole animals within each 25-cow herd.

Average annual pasture costs per acre were $96.68, $100.59, $104.50, and $108.41 for Systems I, II, III, and IV, respectively. Surplus forage growth from pastures was harvested for hay using a mower-conditioner and Heston Stacker. The average cost per ton for hay harvesting was $14.07. Detailed cost budgets for pasture production and hay harvesting are shown in Appendix Tables 1 through 9.

A summary of costs and returns per cow for the four pasture management systems is shown in Table 7. (Detailed budgets of costs and returns for the four systems are shown in Appendix Tables 10 through 13. Selected cattle prices are presented in Appendix Table 14.)

Steers born in the fall during the 4-year study brought 14 percent more per pound at weaning, on the average, than calves born in the spring (Appendix Table 14). During the course of the study, this represented an average of $5 per hundredweight. There was a 17 percent difference, or $6 per hundredweight, in the price of fall and spring heifers during this same period (Appendix Table 14).

Net costs were lowest with System II at 44 cents per pound of marketable

Table 7. — Summary of costs and returns per cow for four pasture management systems, 1972-76

Item	Pasture system			
	I	II	III	IV
	Dollars			
Total returns	195.66	210.31	193.71	177.95
Total costs[1]	222.03	223.32	226.22	225.14
Returns to management	-26.37	-13.01	-32.51	-47.19
Returns per acre to land and management	- 7.81	4.16	-12.09	-24.34
Net cost per pound[2]	0.49	0.44	0.50	0.54
Pounds calf sold per cow	311.8	361.5	339.4	334.7

[1] Includes all costs except management.

[2] (Total costs minus cull cow sales minus surplus hay sales) divided by pounds of calf sold per cow.

calf. Net costs with Systems I and II during the 4-year study were 49 cents and 50 cents, respectively, per pound of marketable calf. Net costs were highest — 54 cents per pound — with System IV.

Net returns per cow ranked in the same order as cost per pound of marketable calf. However, none of the four systems provided returns above total costs when land rent was charged at $15 per acre and interest on investment capital was included at 8 percent per year. System II almost broke even, yielding an annual land rent of $4.16 per acre after accounting for 8 percent interest on investment in livestock and equipment.

Conclusions

The pasture system including 25 acres of bermudagrass overseeded with winter annuals and 5 acres of creep grazing for calves yielded the greatest return to land and management. Calves born in the fall were worth more per hundredweight than those born in the spring. Creep grazing was economically feasible for a fall calving program but not for spring-dropped calves. Both sex of calf and calving season had significant effects on weaning weights. However, there were no significant differences in reproductive performance as measured by calving interval, percent calf crop,and cows diagnosed as pregnant. Results of this study indicated increased stocking rates and a shift to fall calving would have yielded greater net returns to land and management.

While results of this study showed that all systems failed to provide a market rate of return to all resources used, it must be recognized that the study was conducted during the bottom of the cattle price cycle. It was shown that the most efficient of the four systems evaluated (System II) provided some economic rent to land even at the low price levels. At normal price levels, all systems would provide market rates of return to resources. System II provided the lowest net cost per pound of calf sold. The net cost per pound for System II was 10 percent lower than that for System I and 19 percent lower than that for System IV. Consequently, it may be concluded that the forage program has a substantial effect upon the cost of production and the producer's ability to compete for resources.

Appendix Table 1. — Equipment, fertilizer, seed, and labor costs for 30-acre pasture units, West Louisiana Experiment Station, 1972-76

Pasture System	Temporary winter[1]	Temporary summer[2]	Sodseeded winter[3]	Permanent summer[4]	Prorated permanent estab. cost[5]	Annual cost for 30 acres	Avg. annual cost/A.
I[6]	—	—	$1,717.20	$1,083.30	$100.00	$2,900.50	$ 96.68
II[7]	$310.00	$289.00	$1,431.00	$ 902.75	$ 85.00	$3,017.75	$100.59
III[8]	$620.00	$578.00	$1,144.80	$ 722.20	$ 70.00	$3,135.00	$104.50
IV[9]	$930.00	$867.00	$ 858.60	$ 541.65	$ 55.00	$3,252.25	$108.41

[1] Temporary winter pasture cost/A. (wheat, rye, and ryegrass) = $62.

[2] Temporary summer pasture cost/A. (millet) = $57.80.

[3] Sodseeded permanent pasture cost/A. (ryegrass, crimson clover, white clover) = $57.24.

[4] Permanent summer pasture cost/A. (bermudagrass or bahiagrass) = $36.11.

[5] Annual prorated establishment cost for Coastal bermuda (10 yr.) = $4/A., and for common bermuda (10 yr.) = $3/A.

[6] 30 acres permanent pasture.

[7] 5 acres temporary and 25 acres permanent pasture.

[8] 10 acres temporary and 20 acres permanent pasture.

[9] 15 acres temporary and 15 acres permanent pasture.

Appendix Table 2. — Equipment and labor costs for preparing a seedbed, fertilizing, and planting 1 acre of temporary pasture, 1972-76

Operation	Implement Hrs./A.	Tractor Hrs./A.	Man Hrs./A.	Implement Cost/A.	Tractor Cost/A.	Labor Cost/A.	Total Cost/A.
Disking	1.00	1.00	1.00	$2.28	$3.46	$2.05	$ 7.79
Harrowing	0.20	0.20	0.20	$0.04	$0.69	$0.41	$ 1.14
Fertilizing	0.50	0.25	0.25	$0.46	$0.87	$0.51	$ 1.84
Seeding	0.25	0.25	0.25	$0.52	$0.87	$0.51	$ 1.90
Cultipacking	0.30	0.30	0.30	$0.20	$1.04	$0.62	$ 1.86
Topdressing	0.25	0.25	0.25	$0.23	$0.87	$0.51	$ 1.61
Total specified cost per acre				$3.73	$7.80	$4.61	$16.14

Appendix Table 3. — Seed and fertilizer costs for 1 acre of temporary winter pasture (wheat, rye, and ryegrass), 1972-76

Seed and fertilizer per acre	Cost per acre
Lime (prorated over 4-yr. period) (1 ton/4 yrs. ÷ 2)	$ 1.64
200 lbs. 6-24-24 @ $125.70 per ton	$12.57
300 lbs. ammonium nitrate @ $123.00 per ton	$18.45
30 lbs. rye @ $0.09 per lb.	$ 2.70
30 lbs. wheat @ $0.10 per lb.	$ 3.00
25 lbs. ryegrass @ $0.30 per lb.	$ 7.50
Total specified cost per acre	$45.86
Total cost per acre for equipment, labor, seed, and fertilizer ($16.14 + $45.86)	$62.00

Appendix Table 4. — Seed and fertilizer costs for 1 acre of temporary summer pasture (millet), 1972-76

Seed and fertilizer per acre	Cost per acre
Lime (prorated over 4-yr. period) (1 ton/4 yrs. ÷ 2)	$ 1.64
200 lbs. 6-24-24 @ $125.70 per ton	$12.57
300 lbs. ammonium nitrate @ $123 per ton	$18.45
30 lbs. millet @ $0.30 per lb.	$ 9.00
Total specified cost per acre	$41.66
Total cost per acre for equipment, labor, seed, and fertilizer ($16.14 + $41.66)	$57.80

Appendix Table 5. — Equipment and labor costs for fertilizing 1 acre of permanent summer pasture, 1972-76

Operation	Implement Hrs./A.	Tractor Hrs./A.	Man Hrs./A.	Implement Cost/A.	Tractor Cost/A.	Labor Cost/A.	Total Cost/A.
Fertilizing	0.50	0.25	0.25	$0.46	$0.87	$0.51	$1.84
Topdressing	0.25	0.25	0.25	$0.23	$0.87	$0.51	$1.61
Total specified cost per acre				$0.69	$1.74	$1.02	$3.45

Appendix Table 6. — Fertilizer cost for 1 acre of permanent summer pasture, 1972-76

Fertilizer per acre	Cost per acre
Lime (prorated over 4-yr. period) (1 ton/4 yrs. ÷ 2)	$ 1.64
200 lbs. 6-24-24 @ $125.70 per ton	$12.57
300 lbs. ammonium nitrate @ $123 per ton	$18.45
Total specified cost per acre	$32.66
Total cost per acre for equipment, labor, and fertilizer ($3.45 + $32.66)	$36.11

Appendix Table 7. — Equipment and labor costs for sodseeding and fertilizing 1 acre of permanent pasture, 1972-76

Operation	Implement Hrs./A.	Tractor Hrs./A.	Man Hrs./A.	Implement Cost/A.	Tractor Cost/A.	Labor Cost/A.	Total Cost/A.
Fertilizing	0.50	0.25	0.25	$0.46	$0.87	$0.51	$1.84
Seeding	0.25	0.25	0.25	$0.52	$0.87	$0.51	$1.90
Topdressing	0.25	0.25	0.25	$0.23	$0.87	$0.51	$1.61
Total specified cost per acre				$1.21	$2.61	$1.53	$5.35

Appendix Table 8. — Seed and fertilizer costs for 1 acre of sodseeded permanent pasture (ryegrass, crimson clover, and white clover), 1972-76

Seed and fertilizer per acre	Cost per acre
Lime (prorated over 4-yr. period) (1 ton/4 yrs. ÷ 2)	$ 1.64
200 lbs. 6-24-24 @ $125.70 per ton	$12.57
300 lbs. ammonium nitrate @ $123 per ton	$18.45
20 lbs. ryegrass @ $0.30 per lb.	$ 6.00
15 lbs. crimson clover @ $0.63 per lb.	$ 9.45
3 lbs. white clover @ $1.26 per lb.	$ 3.78
Total specified cost per acre	$51.89
Total cost per acre for equipment, labor, seed, and fertilizer ($5.35 + $51.89)	$57.24

Appendix Table 9. — Hay harvesting costs per ton, West Louisiana Experiment Station, 1972-76

Operation	Performance rate	Tractor	Equipment	Labor	Total
		Dollars			
Mowing-conditioning	.4 hr./ton	—	1.78	.82	2.60
Stacking	.6 hr./ton	2.03	5.95	1.23	9.21
Moving stacks	.3 hr./ton	1.02	.62	.62	2.26
Total cost per ton (1-ton yield/A.)		3.05	8.35	2.67	14.07

Appendix Table 10. — Costs and returns for 25 cows, System I, 90 percent calf crop, West Louisiana Experiment Station, 1972-76

Item	Amount	
	25 cows	per cow
	Dollars	
Returns:		
Fall steer calf sales (34.31 cwt. @ $42.94)	1,473.27	58.93
Fall heifer calf sales (15.27 cwt. @ $40.86)	623.93	24.96
Spring steer calf sales (16.32 cwt. @ $37.57)	613.14	24.53
Spring heifer calf sales (12.05 cwt. @ $34.92)	420.79	16.83
Cull cow sales (35 cwt. @ $29.87)	1,045.45	41.82
Surplus hay sales (16.9 tons @ $42.29)	714.70	28.59
Total returns	4,891.28	195.66
Costs:		
Pasture (30 acres @ $96.68)	2,900.40	116.02
Hay harvesting (39.6 tons @ $14.07)	557.17	22.29
Molasses (15.7 cwt. @ $5.88)	92.32	3.69
Protein blocks (16.4 cwt. @ $6.01)	98.56	3.94
Medication (31 head @ $5.50)	170.50	6.82
Labor for cattle (190 hrs. @ $2.09)	397.10	15.88
Truck operation (750 miles @ $0.10)	75.00	3.00
Buildings, fences and equip. (25 head @ $5.20)	130.00	5.20
Interest:		
Buildings, fences & equip. ($750 @ 8%)	60.00	2.40
Livestock ($7,350 @ 8%)	588.00	23.52
Marketing costs:		
Hauling (4 head @ $1.10)	4.40	0.18
Commission ($1,045.45 @ 5%)	52.27	2.09
Land rent (30 acres @ $15)	450.00	18.00
Total costs	5,575.72	222.03
Net returns to management	-684.44	-26.37
Net returns per acre		-7.81
Net cost per pound		0.486
Pounds calf sold per cow		311.8

Appendix Table 11. — Costs and returns for 25 cows, System II, 90 percent calf crop, West Louisiana Experiment Station, 1972-76

Item	Amount	
	25 cows	per cow
	Dollars	
Returns:		
Fall steer calf sales (40.49 cwt. @ $42.94)	1,738.64	69.55
Fall heifer calf sales (19.00 cwt. @ $40.86)	776.34	31.05
Spring steer calf sales (18.08 cwt. @ $37.57)	679.27	27.17
Spring heifer calf sales (12.80 cwt @ $34.92)	446.98	17.88
Cull cow sales (35 cwt. @ $29.87)	1,045.45	41.82
Surplus hay sales (13.5 tons @ $42.29)	570.92	22.84
Total returns	5,257.60	210.31
Costs:		
Pasture (30 acres @ $100.59)	3,017.70	120.71
Hay harvesting (33.6 tons @ $14.07)	472.75	18.91
Molasses (14.5 cwt. @ $5.88)	85.26	3.41
Protein blocks (13.3 cwt. @ $6.01)	79.93	3.20
Medication (31 head @ $5.50)	170.50	6.82
Labor for cattle (190 hrs. @ $2.09)	397.10	15.88
Truck operation (750 mi. @ $.10)	75.00	3.00
Buildings, fences & equip. (25 head @ $5.20)	130.00	5.20
Interest:		
Buildings, fences & equip. ($750 @ 8%)	60.00	2.40
Livestock ($7,350 @ 8%)	588.00	23.52
Marketing costs:		
Hauling (4 head @ $1.10)	4.40	0.18
Commission ($1,045.45 @ 5%)	52.27	2.09
Land rent (30 acres @ $15)	450.00	18.00
Total costs	5,582.91	223.32
Net returns to management	-325.31	-13.01
Net returns per acre		4.16
Net cost per pound		0.439
Pounds calf sold per cow		361.5

Appendix Table 12. — Cost and returns for 25 cows, System III, 90 percent calf crop, West Louisiana Experiment Station, 1972-76

Item	Amount 25 cows	 per cow
	-------------Dollars-------------	
Returns:		
Fall steer calf sales (36.86 cwt. @ $42.94)	1,582.77	63.31
Fall heifer calf sales (16.55 cwt. @ $40.86)	676.23	27.05
Spring steer calf sales (17.80 cwt. @ $37.57)	668.75	26.75
Spring heifer calf sales (13.64 cwt. @ $34.92)	476.31	19.05
Cull cow sales (35 cwt. @ $29.87)	1,045.45	41.82
Surplus hay sales (9.3 tons @ $42.29)	393.30	15.73
Total returns	4,842.81	193.71
Costs:		
Pasture (30 acres @ $104.50)	3,135.00	125.40
Hay harvesting (30.1 tons @ $14.07)	423.51	16.94
Molasses (16.4 cwt. @ $5.88)	96.43	3.86
Protein blocks (12.2 cwt. @ $6.01)	73.32	2.93
Medication (31 head @ $5.50)	170.50	6.82
Labor for cattle (190 hrs. @ $2.09)	397.10	15.88
Truck operation (750 miles @ $0.10)	75.00	3.00
Buildings, fences and equip. (25 head @ $5.20)	130.00	5.20
Interest:		
Buildings, fences & equip. ($750 @ 8%)	60.00	2.40
Livestock ($7,350 @ 8%)	588.00	23.52
Marketing costs:		
Hauling (4 head @ $1.10)	4.40	0.18
Commission ($1,045.45 @ 5%)	52.27	2.09
Land rent (30 acres @ $15)	450.00	18.00
Total costs	5,655.53	226.22
Net returns to management	-812.72	-32.51
Net returns per acre		-12.09
Net cost per pound		0.497
Pounds calf sold per cow		339.4

Appendix Table 13. — Costs and returns for 25 cows, System IV, 90 percent calf crop, West Louisiana Experiment Station, 1972-76

Item	Amount 25 cows	 per cow
	----------Dollars	----------
Returns:		
Fall steer calf sales (38.03 cwt. @ $42.94)	1,633.01	65.32
Fall heifer calf sales (17.42 cwt. @ $40.86)	711.78	28.47
Spring steer calf sales (16.42 cwt. @ $37.57)	616.90	24.68
Spring heifer calf sales (11.80 cwt. @ $34.92)	412.06	16.48
Cull cow sales (35 cwt. @ $29.87)	1,045.45	41.82
Surplus hay sales (0.7 ton @ $42.29)	29.60	1.18
Total returns	4,448.80	177.95
Costs:		
Pasture (30 acres @ $108.41)	3,252.30	130.09
Hay harvesting (19 tons @ $14.07)	267.33	10.69
Molasses (14.9 cwt. @ $5.88)	87.61	3.50
Protein blocks (15.7 cwt. @ $6.01)	94.36	3.77
Medication (31 head @ $5.50)	170.50	6.82
Labor for cattle (190 hours @ $2.09)	397.10	15.88
Truck operation (750 miles @ $0.10)	75.00	3.00
Buildings, fences & equip. (25 head @ $5.20)	130.00	5.20
Interest:		
Buildings, fences & equip. ($750 @ 8%)	60.00	2.40
Livestock ($7,350 @ 8%)	588.00	23.52
Marketing costs:		
Hauling (4 head @ $1.10)	4.40	0.18
Commission ($1,045.45 @ 5%)	52.27	2.09
Land rent (30 acres @ $15)	450.00	18.00
Total costs	5,628.87	225.14
Net returns to management	-1,180.07	-47.19
Net returns per acre		-24.34
Net cost per pound		0.544
Pounds calf sold per cow		334.7

Appendix Table 14. — Selected beef cattle prices, Louisiana 1973-76

Type of animal	Year	June	August	October	December
		Dollars per hundredweight			
Steers	1973	66.43	72.36	62.27	52.20
	1974	34.12	31.88	27.53	26.95
	1975	31.70	29.76	29.49	33.43
	1976	40.58	36.63	33.73	34.94
	Average	43.21	42.66	38.26	36.88
Heifers	1973	64.86	70.40	59.79	49.56
	1974	34.13	31.65	26.34	25.64
	1975	29.98	27.93	27.12	30.07
	1976	35.01	32.84	29.87	30.95
	Average	41.00	40.71	35.78	34.06
Cows	1973	32.79	38.81	35.27	32.96
	1974	29.51	35.88	37.63	38.85
	1975	21.95	21.06	21.76	23.27
	1976	25.51	25.74	23.62	24.38
	Average	27.44	30.37	29.57	29.87

Source: Selected issues "Livestock Market Report," Market News Service, Louisiana Department of Agriculture, Baton Rouge, Louisiana.

Appendix Table 15. — Average weights and value of calf crops by pasture system, 90 percent calf crop, 71 percent fall calves and 29 percent spring calves, West Louisiana Experiment Station, 1973-76[1]

Pasture system	Type of animal	No. of animals	Average weaning wt.	Total wt. shrink 2%	Price per cwt.	Total value per herd
			(Lbs.)	(Cwt.)	Dollars	
I	Fall steers	8	437.6	34.31	42.94	1,473.27
	Fall heifers	4	389.5	15.27	40.86	623.93
	Spring steers	4	416.2	16.32	37.57	613.14
	Spring heifers	3	409.7	12.05	34.92	420.79
II	Fall steers	8	516.5	40.49	42.94	1,738.69
	Fall heifers	4	484.7	19.00	40.86	776.34
	Spring steers	4	461.1	18.08	37.57	679.27
	Spring heifers	3	435.3	12.80	34.92	446.98
III	Fall steers	8	470.1	36.86	42.94	1,582.77
	Fall heifers	4	422.1	16.55	40.86	676.23
	Spring steers	4	454.0	17.80	37.57	668.75
	Spring heifers	3	463.8	13.64	34.92	476.31
IV	Fall steers	8	485.1	38.03	42.94	1,633.01
	Fall heifers	4	444.3	17.42	40.86	711.78
	Spring steers	4	418.9	16.42	37.57	616.90
	Spring heifers	3	401.3	11.80	34.92	412.06

[1] Four replacements saved from fall heifers.

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The Response Of Sweet Potatoes to Fertilizer Phosphorus and Potassium As Related to Levels of These Elements Available in the Soil

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The Response of Sweet Potatoes to Fertilizer Phosphorus and Potassium as Related to Levels of These Elements Available in the Soil

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Introduction

Sweet potatoes are grown in Louisiana on several different kinds of soil, ranging from the light Coastal Plain group through the medium-textured Mississippi River Terrace and Loessial Hill group into certain areas of the Mississippi River and the Red River alluviums. The major portion of the commercial sweet potato crop is produced on the silt loam soils of the Mississippi River Terrace or Loessial Hills, however. These soils vary widely in fertility levels, as shown by Brupbacher et al. *(4),*[3] as a result of different cropping practices and methods of soil management used by growers of sweet potatoes in the state. In some cases, the extractable[4] phosphorus content of these soils appears to have been increased somewhat from the original level present in the native state before the soils were put into crop production. The native levels were characteristically relatively low. In other cases, poor soil management including inadequate fertilization has resulted in very little improvement in the amount of easily extractable[4] phosphorus in the soil, as indicated by soil testing procedures *(3, 4)*.

A similar situation exists with respect to the amount of easily extractable[5] potassium present in these soils *(3, 4)*. The potassium content now ranges from a level below that which is characteristic of original native levels to a point which indicates that some accumulation of potassium has occurred in some fields as a result of local fertilization and cropping practices *(4)*.

From a research standpoint, it is important to determine the levels of phosphorus and potassium in these soils, as indicated by soil analysis, beyond which a response by sweet potatoes to fertilizer phosphorus and/or potassium is not likely to be obtained. Since crop plants vary so widely in their ability to absorb enough phosphorus and potassium from a given soil at a certain level of extractability, it becomes necessary to determine the soil levels at which a response may be expected for each crop plant species separately. In this way, a relationship may be established between the extracting power of the solution used in soil analysis and the absorptive capacity and nutrient requirements of the particular crop plant involved. This relationship must be established for phosphorus and potassium individually, although they may be applied together in an experimental fertilizer. Primarily for reasons of practicality, plant response in terms of yield in its various components is the criterion usually used to measure the effectiveness of applied fertilizers, although the total uptake and/or concentration of the elements in the foliage may be additional criteria employed. Other influences of fertilization may also be measured such as fruit or vegetable composition, earliness, keeping quality, processing behavior, and resistance to cold, drought and pests.

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[3] Italic numbers in parentheses refer to Literature Cited, page 41.

[4] Extractable with 0.1 *N* HCl + 0.03 *N* NH_4F at a ratio of 1 part soil to 20 parts extractant.

[5] Extractable with 0.1 *N* HCl at a ratio of 1 part soil to 20 parts extractant.

This type of study has been conducted with rice on the Coastal Prairie soils of Southwest Louisiana by Peterson et al. *(18)*. In that study a definite correlation was shown between the amounts of ''available'' phosphorus and potassium present in the soil and the extent of the response to fertilizer phosphorus and potassium by the crop.

This approach to problems in soil fertility has been widely used by agronomists with other field crops on other types of soil, but much of the information developed in these studies remains unpublished except in calibration form which county agents and others use in interpreting the results of soil analysis and in making fertilizer recommendations to farmers.

As for sweet potatoes grown on Mississippi Terrace or Loessial Hill soil, a large amount of time and effort has been devoted to determining the proper rate of fertilization to be used *(5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16)*. Many of these studies were not designed, however, to develop a quantitative relationship between the level of a particular nutrient in the soil and the amount of it that should be applied in the fertilizer in order to obtain maximum yield. Most of these experiments involved complete fertilizers of different grades applied at different rates, and in some cases little attention was given to the levels of extractability of phosphorus and potassium in the soil before the experimental fertilizers were applied. Because of this situation, it was difficult to determine the effect that the level of phosphorus or potassium in the soil might have had on the extent of plant response to fertilizer phosphorus and potassium. Yet, in some of this work it has been found that sweet potatoes did respond significantly to applications of phosphorus and/or potassium *(6, 8, 9)*.

Fontenot et al. *(6)* reported that sweet potatoes grown on Lintonia (Memphis) silt loam at Grand Coteau responded significantly to phosphorus applications during an 8-year study. They also obtained definite responses to phosphorus and potassium in experiments on a Memphis silt loam at St. Francisville. At Chase, where the plots were located on Richland (Loring) silt loam, best yields were obtained from heavy applications of phosphorus and moderate use of potassium in the fertilizer. In Baton Rouge, where the experimental soil was Olivier silt loam, a positive response was obtained again from the inclusion of phosphorus and potassium in the fertilizer.

In other experiments by Miller et al. *(10, 11, 12, 13, 14, 15, 16)* in which the levels of extractable phosphorus and potassium in the soil were determined before experimental fertilizers were applied, some relationships were indicated between the levels of ''soil'' phosphorus and potassium and the extent of response to these elements applied in the fertilizer. Again, however, these experiments were not designed to provide a clear conception of this relationship, so only general inferences were possible from the experimental data obtained. Therefore, since correlation data are not available on extractable levels of soil phosphorus or potassium and response of sweet potatoes to these elements as fertilizer, and since the science of soil analysis is becoming more widely used and calibrated for more crops, it appeared desirable and warranted to study this relationship with sweet potatoes grown on the soils on which most of the crop is produced in the state.

Materials and Methods

Between 1966 and 1975, 18 individual experiments were conducted to study the response by Centennial sweet potatoes to fertilizer phosphorus and potassium as influenced by the levels of these elements which were easily extractable from the soil. Some of these experiments were located in northeastern Louisiana on the Macon Ridge soil area. Others were located in southern Louisiana, either on Loessial Hill soil or Mississippi River Terrace soil. The exact location of the individual experiments is given in Table 1, as well as the series name of the soil at each location. These sites were selected for the study because of their soil type and their widely varying levels of easily-extractable phosphorus and potassium before experimental fertilizers were applied. In this way, it was intended to determine the extent of sweet potato response to fertilizer phosphorus and potassium on soils that already contained different levels of these elements, as indicated by soil analysis *(3, 4)*. The amounts of extractable phos-

Table 1. — Identification of the experimental locations

Location	Date	Soil Series*	Farm	Nearest Town	Parish	Date Soil Sampled
1	1966	Olivier-Calhoun	Sweet Potato Res. Center	Chase	Franklin	June 2, 1966
2	1966	Loring	W. H. Turner	Oak Grove	West Carroll	June 3, 1966
3	1967	Loring	Idlewild Expt. Station	Clinton	East Feliciana	May 1, 1967
4	1967	Loring-Olivier-Calhoun	Sweet Potato Res. Center	Chase	Franklin	April 21, 1967
5	1968	Calhoun	Sweet Potato Res. Center	Chase	Franklin	May 7, 1968
6	1968	Providence	Idlewild Expt. Station	Clinton	East Feliciana	May 23, 1968
7	1969	Granada	Sweet Potato Res. Center	Chase	Franklin	April 29, 1969
8	1970	Calhoun	Sweet Potato Res. Center	Chase	Franklin	April 22, 1970
9	1971	Calhoun	Brown McLemore	Gilbert	Franklin	April 28, 1971
10	1971	Olivier-Calloway-Calhoun	Buddy Thornhill	Wisner	Franklin	April 28, 1971
11	1971	Olivier	Idlewild Expt. Station	Clinton	East Feliciana	April 16, 1971
12	1972	Providence-Calloway	Idlewild Expt. Station	Clinton	East Feliciana	May 2, 1972
13	1973	Providence	Idlewild Expt. Station	Clinton	East Feliciana	May 30, 1973
14	1973	Calhoun	Sweet Potato Res. Center	Chase	Franklin	May 18, 1973
15	1974	Providence	Idlewild Expt. Station	Clinton	East Feliciana	May 9, 1974
16	1974	Calhoun	Sweet Potato Res. Center	Chase	Franklin	May 7, 1974
17	1975	Providence	Idlewild Expt. Station	Clinton	East Feliciana	May 20, 1975
18	1975	Olivier	LSU Campus	Baton Rouge	East Baton Rouge	May 20, 1975

*Each soil used was of the silt loam textural class.

phorus,[6] potassium,[7] calcium,[7] and magnesium,[7] and the pH of the soil at each of the experimental sites are shown in Table 2. Results have shown that the two extractants for cations on these soils are comparable *(3)*[7].

In the phosphorus experiments, a wide range in the level of phosphorus is shown, with the lowest value of 5 ppm in the Providence soil at Clinton in 1975 to a high of 412 ppm for the Olivier soil at Baton Rouge in 1975. Other locations fell between these two extremes in extractable phosphorus.

A somewhat narrower range was shown in the extractable potassium levels among the various locations, with a low value of 35 ppm in the Providence soil at Clinton in 1973 to a high point of 185 ppm in the Calhoun soil at Chase in 1970. Other soils showed intermediate contents of potassium. In the potassium experiments, the phosphorus levels ranged from 5 ppm in the Providence soil at Clinton in 1975 to 398 ppm in the Oliver soil at Baton Rouge in 1975. Alternate sites were somewhere in-between in phosphorus content. The range in potassium in these tests was from 50 ppm in the Providence soil at Clinton in 1973 to 200 ppm in the Calhoun soil at Chase in 1970. The other soils were intermediate in potassium content.

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[6] Extracted with 0.1 *N* NH_4F at a ratio of 1 part soil and 20 parts extractant.

[7] Extracted with 0.1 *N* HCl at a ratio of 1 part soil to 20 parts extractant until 1971, and with neutral 1.0 *N* ammonium acetate at a ratio of 1 part soil to 10 parts extractant thereafter.

Table 2. — The levels of available* nutrients present in the soils at the different experimental locations before fertilizers were applied for the sweet potato crops, 1966-75

				Phospharus Experiment						Potassium Experiment					
Location	Nearest Town	Soil Series**	Date	P	K	Ca	Mg	pH	O.M.	P	K	Ca	Mg	pH	O.M.
1	Chase	Olivier-Calhoun	1966	52	140	430	161	6.0	—	52	150	380	133	5.8	—
2	Oak Grove	Loring	1966	55	95	220	178	5.3	—	55	120	300	204	5.4	—
3	Clinton	Loring	1967	45	110	320	123	4.9	—	25	110	350	185	4.9	—
4	Chase	Loring-Olivier-Calhoun	1967	76	170	420	124	4.8	—	93	145	420	100	4.6	—
5	Chase	Calhoun	1968	44	105	240	109	5.1	—	34	95	240	111	5.0	—
6	Clinton	Providence	1968	10	85	450	260	5.5	—	7	80	390	253	5.2	—
7	Chase	Granada	1969	61	125	240	152	5.6	—	56	100	270	122	5.4	—
8	Chase	Calhoun	1970	146	185	790	125	4.9	1.14	271	200	790	129	4.8	0.96
9	Gilbert	Calhoun	1971	84	110	800	316	6.6	1.01	62	80	720	279	6.4	0.81
10	Wisner	Olivier-Calloway-Calhoun	1971	56	100	960	112	6.3	0.99	58	90	800	90	6.3	0.99
11	Clinton	Olivier	1971	14	50	240	86	5.1	1.59	13	55	240	79	5.1	1.61
12	Clinton	Providence-Calloway	1972	7	90	240	98	5.5	1.64	10	80	240	92	5.6	1.74
13	Clinton	Providence	1973	20	35	360	92	5.4	2.00	5	50	400	112	5.5	2.10
14	Chase	Calhoun	1973	114	110	360	106	4.9	1.07	102	60	320	94	4.8	0.96
15	Clinton	Providence	1974	14	55	350	124	5.6	1.77	9	64	370	146	5.3	1.95
16	Chase	Calhoun	1974	111	181	480	123	5.2	1.43	107	142	460	119	5.0	0.96
17	Clinton	Providence	1975	5	82	460	141	5.1	1.51	5	87	550	195	5.4	1.82
18	Baton Rouge	Olivier	1975	412	118	390	55	5.6	0.68	398	117	410	58	5.5	0.65

* Phosphorus extracted with 0.1N HC1 + 0.03N NH_4F; other elements extracted with 0.1N HC1 until 1971 and with neutral 1.0 *N* ammonium acetate afterwards. All elemental data expressed as ppm of air-dry soil; organic matter (O.M.) expressed as percent.

** Each soil used was of the silt loam textural class.

Many of the soils might appear to be critically low in the amount of extractable calcium; however, a considerable amount of evidence has accumulated that sweet potatoes can grow well and produce high yields on low-calcium, low-pH soils *(2, 5, 8, 17, 19)*. It has also been demonstrated that they will grow well on a high-pH soil if the soil rot organism is not present *(8, 19)*.

Extractable magnesium was low enough in some of these soils to cause some concern, but it is not known at what point in magnesium extractability sweet potato growth and yield might be hampered. Analytical data on soil organic matter content were not available until 1970. The sites used after that varied from about 1 to 2 percent in organic matter content. These differences were not considered of sufficient magnitude to interfere seriously with the study.

Each experimental site consisted of an area 60 feet wide and 150 feet long. The area was divided into two equal parts 30 feet by 150 feet, one part to be used for the phosphorus experiment and the other part used for the potassium study. Six rows were used for each of the tests, with one guard row between the tests and one guard row on the outside of each test site. Each single plot was 25 feet long and 4 feet wide, with six of these plots occurring in a block. Alleyways 5 feet wide separated the blocks. Six experimental treatments were used in each of the tests and were replicated six times. The treatment plots were arranged in a Latin Square design in order to reduce experimental error to a minimum.

The experimental factors in the phosphorus study were applications of 0, 30, 60, 90, 120, and 150 pounds of P_2O_5 per acre in the form of ordinary superphosphate. In this test, each plot received 30 pounds per acre of nitrogen as ammonium nitrate and 60 pounds per acre of K_2O as muriate of potash in order to prevent these elements from becoming limiting factors in growth and production.

The treatment factors in the potassium study were 0, 30, 60, 90, 120, and 150 pounds per acre of K_20 in the form of muriate of potash. In addition, each plot received 30 pounds per acre of nitrogen as ammonium nitrate and 90 pounds per acre of P_2O_5 as ordinary superphosphate so that these elements were not limiting factors.

All of the fertilizers were applied in the drill at a depth of about 6 inches approximately 2 weeks before planting. The plots were usually planted in May or early June and harvested in September or October, the exact date varying with season because of weather conditions. Slips of the Centennial cultivar were planted 12 inches apart and 5 inches deep on a 4-foot row. The herbicide Amiben[8] was applied immediately after planting at the rate of 4 pounds of active ingredient per acre. Conventional culture followed as necessary to control weeds in the water furrows. No irrigation water was applied to any of the plots during any season. At harvest time, the roots were graded according to regular USDA standards by placing them into Number 1, Number 2, or Cull grade.

Results and Discussion

The yield of Number 1 sweet potatoes at each experimental location as influenced by the extractable phosphorus level in the soil and the phosphorus application rate is shown in Table 3. During the first 2 years of the study, significant responses to P applications were obtained, even on the soil running as high as 76 ppm of P. Three of the tests showed that highly significant responses to P application were obtained, in spite of undesirably high coefficients of variation (c.v.). Then from 1968 through 1971 only two of the experiments showed that real benefits resulted from P applications, the one on the Providence soil at 10 ppm of P and the one on the Olivier soil at 14 ppm of P. The lower c.v. indicated a greater reliability in these tests. After that, the responses were limited to the soils with less than 100 ppm of P in them before fertilization. The intermediate values shown by the c.v. in these tests indicate an intermediate degree of reliability in the results.

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[8] Trade name for the ammonium salt of 3-amino-2,5-dichlorobenzoic acid.

It was interesting to note that of the 18 sites used in the study, the sweet potatoes at 10 of them showed significant responses to P applications while those at nine of them revealed highly significant responses. At those sites where responses were obtained, the effect tended to be curvilinear as the rate of P application was increased; however, by far the largest increase in yield resulted from the first 30-pound increment of P_2O_5 application, especially on those soils that were relatively low in extractable P (Table 3 and Figure 1). Moderate responses were also obtained from the second increment of applied phosphate; however, beyond that rate the response was somewhat erratic, sometimes showing small increases in yield and sometimes decreases, with little relation to the amount of extractable P in the soil before fertilization. It may be noted in Table 2 that even at the eight locations where responses to P application were not statistically significant, in some cases there were strong indications that the plants were responding to P at some level of application, except at the Baton Rouge site in 1975 where the extractable P level was 412 ppm before fertilization.

Table 3. — The yield of Number 1 sweet potatoes at each experimental location as influenced by the available* phosphorus level in the soil and the phosphorus application rate**, 1966-75.

Location	Nearest Town	Date	Soil Series***	P Level in Soil	No. 1 Potatoes (Bushels/Acre)						L.S.D. (.05)	L.S.D. (.01)	C.V. (%)
					P_2O_5 Application Rates								
					0	30	60	90	120	150			
1	Chase	1966	Olivier-Calhoun	52	328	418	446	406	385	404	52	71	10.9
2	Oak Grove	1966	Loring	55	56	106	148	150	120	136	33	44	22.8
3	Clinton	1967	Loring	45	123	196	212	186	196	187	49	NS	22.3
4	Chase	1967	Loring-Olivier-Calhoun	76	118	173	200	212	209	192	45	61	20.0
5	Chase	1968	Calhoun	44	280	302	298	306	308	312	NS	NS	10.4
6	Clinton	1968	Providence	10	89	251	327	347	389	380	31	42	8.6
7	Chase	1969	Granada	61	504	526	527	510	491	555	NS	NS	7.1
8	Chase	1970	Calhoun	146	360	385	370	357	328	379	NS	NS	17.4
9	Gilbert	1971	Calhoun	84	378	451	420	446	387	428	NS	NS	11.8
10	Wisner	1971	Olivier-Calloway-Calhoun	56	274	274	242	297	300	247	NS	NS	25.1
11	Clinton	1971	Olivier	14	168	273	312	306	343	359	34	46	9.5
12	Clinton	1972	Providence-Calloway	7	99	225	256	241	258	270	36	49	13.2
13	Clinton	1973	Providence	20	68	152	173	176	211	229	31	42	15.2
14	Chase	1973	Calhoun	114	322	289	346	366	301	322	NS	NS	13.3
15	Clinton	1974	Providence	14	147	333	347	364	362	373	36	49	9.3
16	Chase	1974	Calhoun	111	272	295	308	298	346	317	NS	NS	16.1
17	Clinton	1975	Providence	5	148	308	333	341	401	364	55	75	14.4
18	Baton Rouge	1975	Olivier	412	285	243	235	245	231	306	NS	NS	26.3

* Phosphorus extracted with 0.1N HCl + 0.03 N NH_4F and expressed as ppm of air-dry soil.

** In addition to the phosphorus application, each plot received 30 pounds of N and 60 pounds of K_2O per acre.

*** Each soil used was of the silt loam textural class.

C.V. = Coefficient of variation.

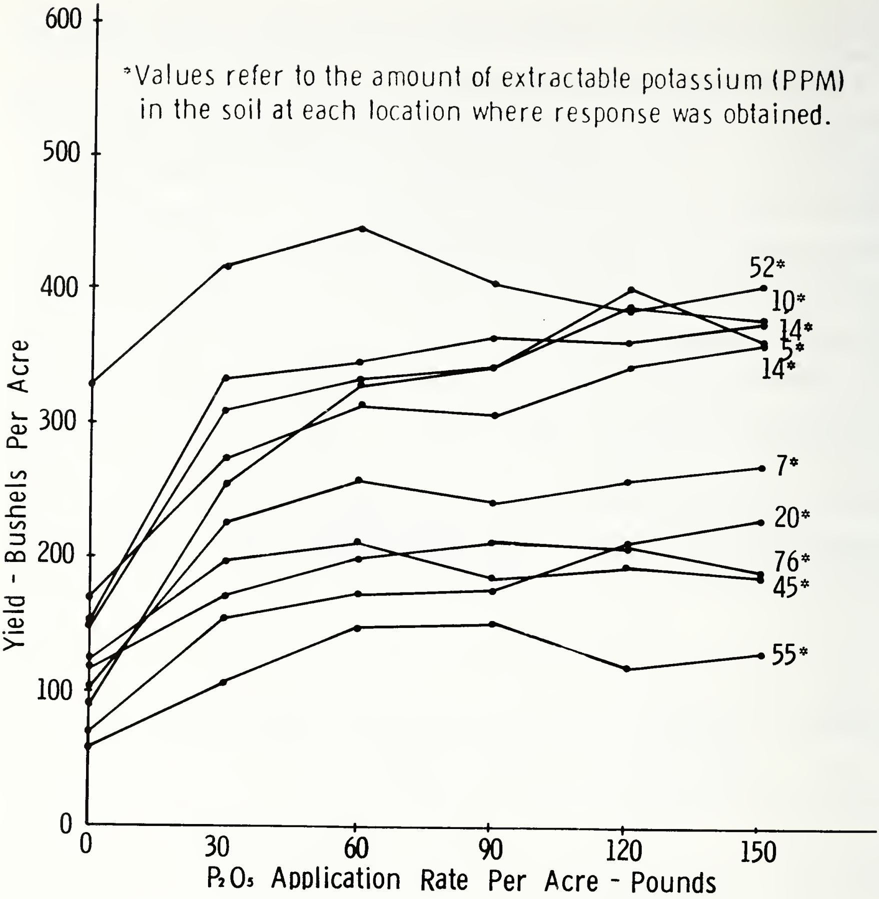

Figure 1. — The yield of Number 1 sweet potatoes at each experimental location where significant responses were obtained as influenced by the available phosphorus level in the soil and the phosphorus application rate, 1966-75.

The influence of the soil level of available P on the response in yield of Number 1 roots to P applications at the 30 pounds of P_2O_5 per acre rate is shown graphically in Figure 2. It was not surprising that the soils with the lower levels of P gave larger response to phosphate applications while those with higher levels showed smaller or no response. In considering all of the locations collectively, this resulted in a negative relationship between these two factors, as shown by the negative correlation coefficient (r value) of -0.67**. This value was highly significant statistically, and the

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**Double asterisks will indicate significance at the .01 level of probability here and throughout this bulletin.

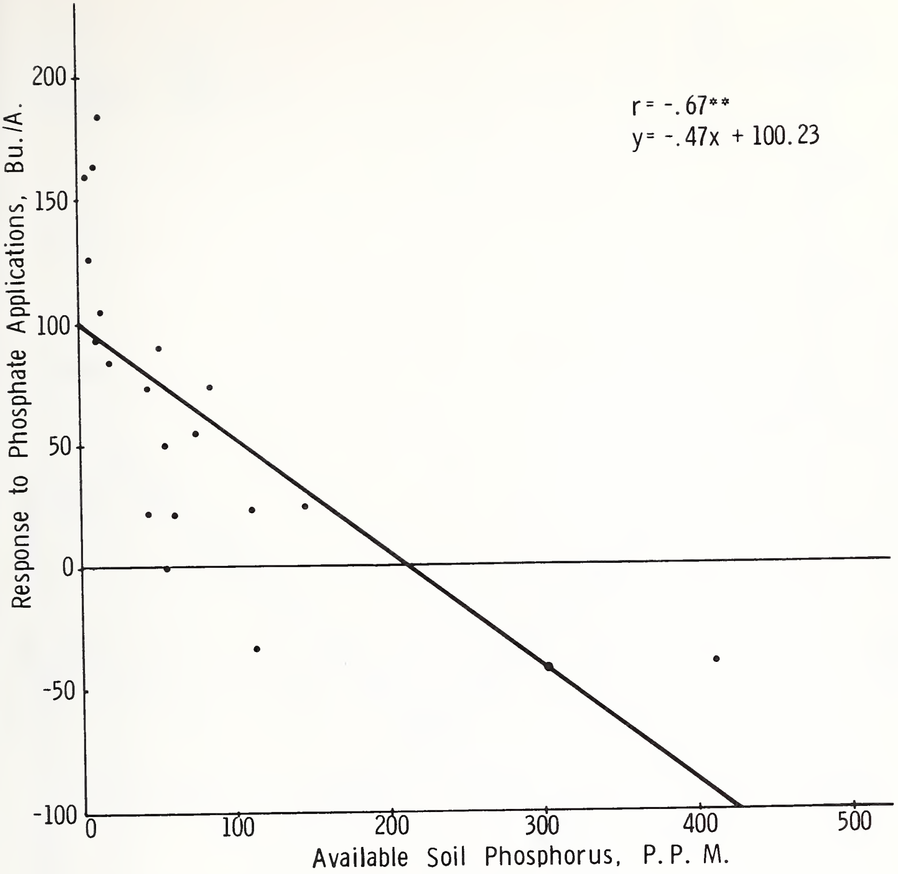

Figure 2. — The response in Number 1 roots by sweet potatoes to fertilizer phosphorus (30 pounds P_2O_5/ acre) as related to the level of available soil phosphorus.

slope of the regression line indicated a definite dependence of response to phosphate application on the level of available P in the soil.

The same type of information concerning the 60 pounds of P_2O_5 per acre rate is presented in Figure 3. Again, the strong negative correlation value of -0.66** indicated that the higher the level of available soil P the lower would be the response to phosphate applications.

Figure 4 shows similar trends when 90 pounds of P_2O_5 per acre were applied. The r value in this case was -0.65**, still strongly suggestive of a true negative relationship between these two variables. Each plot in the phosphorus study received 30 pounds of (nitrogen) N and 60 pounds of K_2O per acre.

Further information on the production of Number 1 roots is given in Figure 5. This is for the treatment receiving 120 pounds of P_2O_5 per acre.

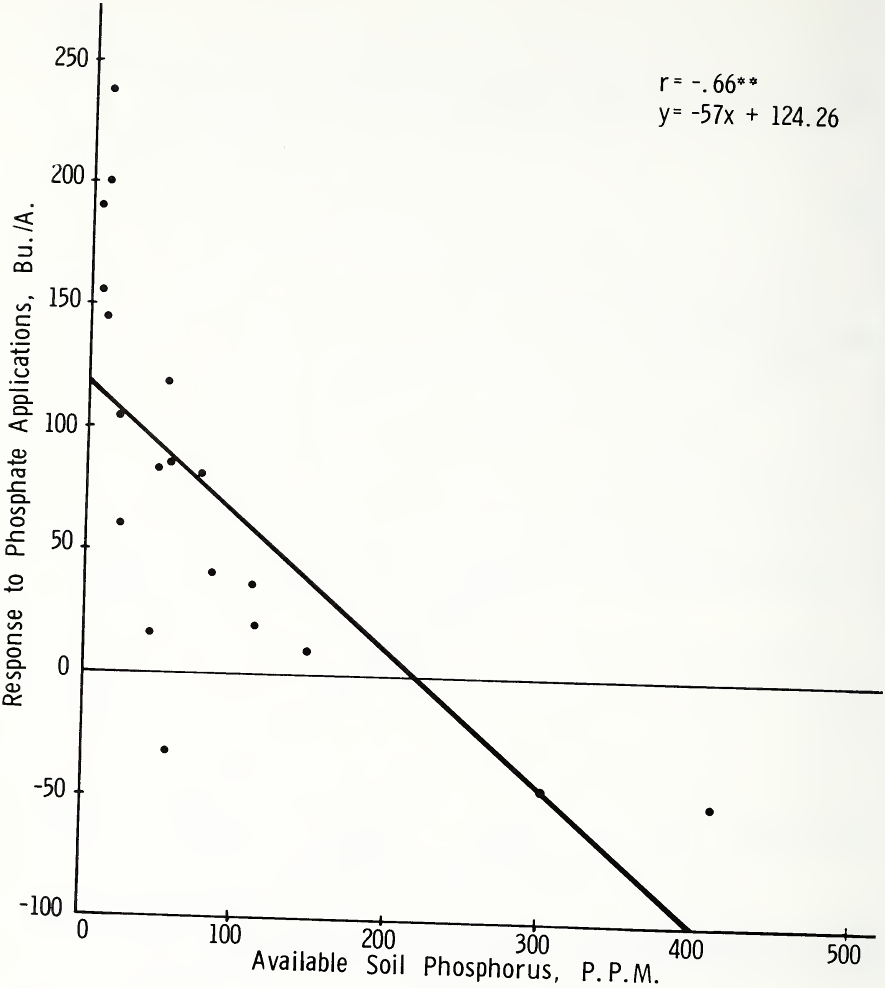

Figure 3. — The response in Number 1 roots by sweet potatoes to fertilizer phosphorus (60 pounds P_2O_5/ acre) as related to the level of available soil phosphorus.

The relationship between the two variables is very similar to those previously shown for the lower rates of phosphate application. The r value was -0.63**.

When 150 pounds of P_2O_5 were applied per acre the relationship between the amount of available P in the soil and the response to applied phosphate was not so strong as it had been when smaller amounts of P had been used (Figure 6). However, the slope of the regression line and the

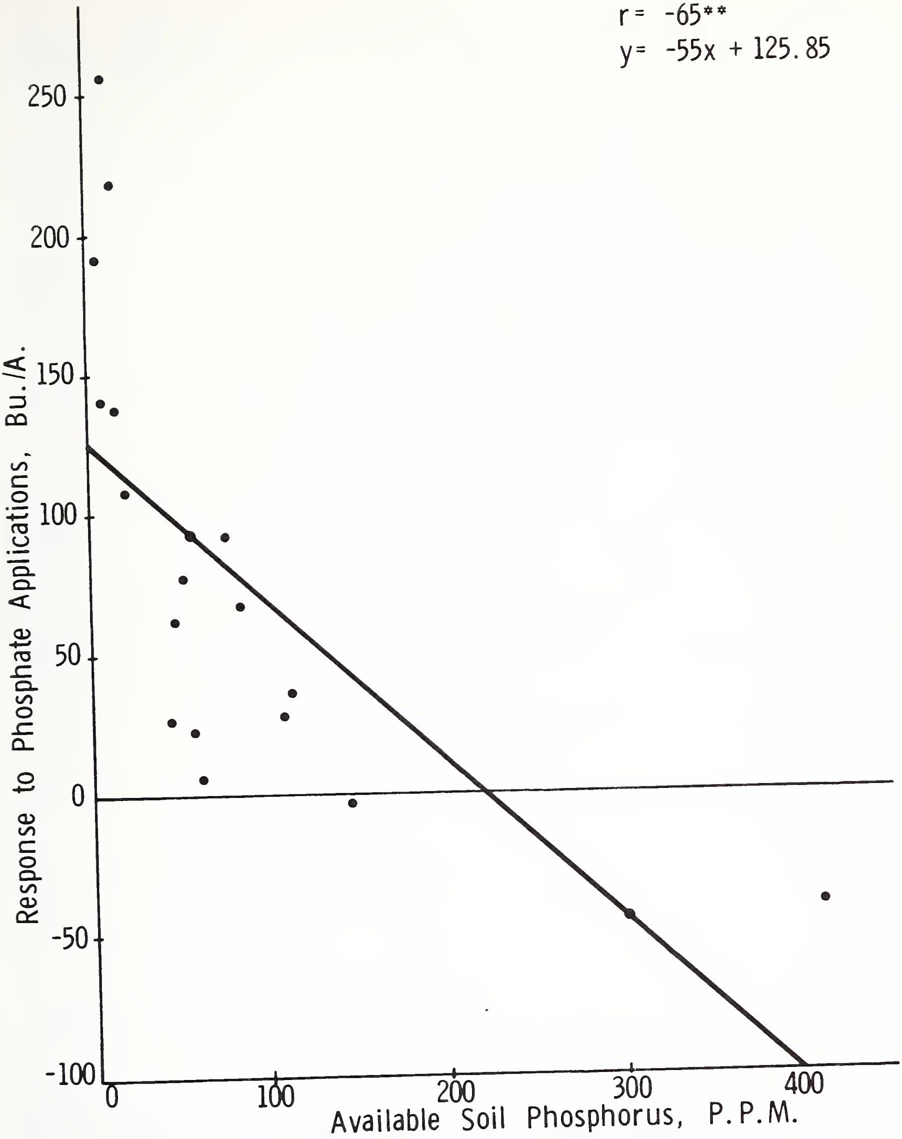

Figure 4. — The response in Number 1 roots by sweet potatoes to fertilizer phosphorus (90 pounds P_2O_5/ acre) as related to the level of available soil phosphorus.

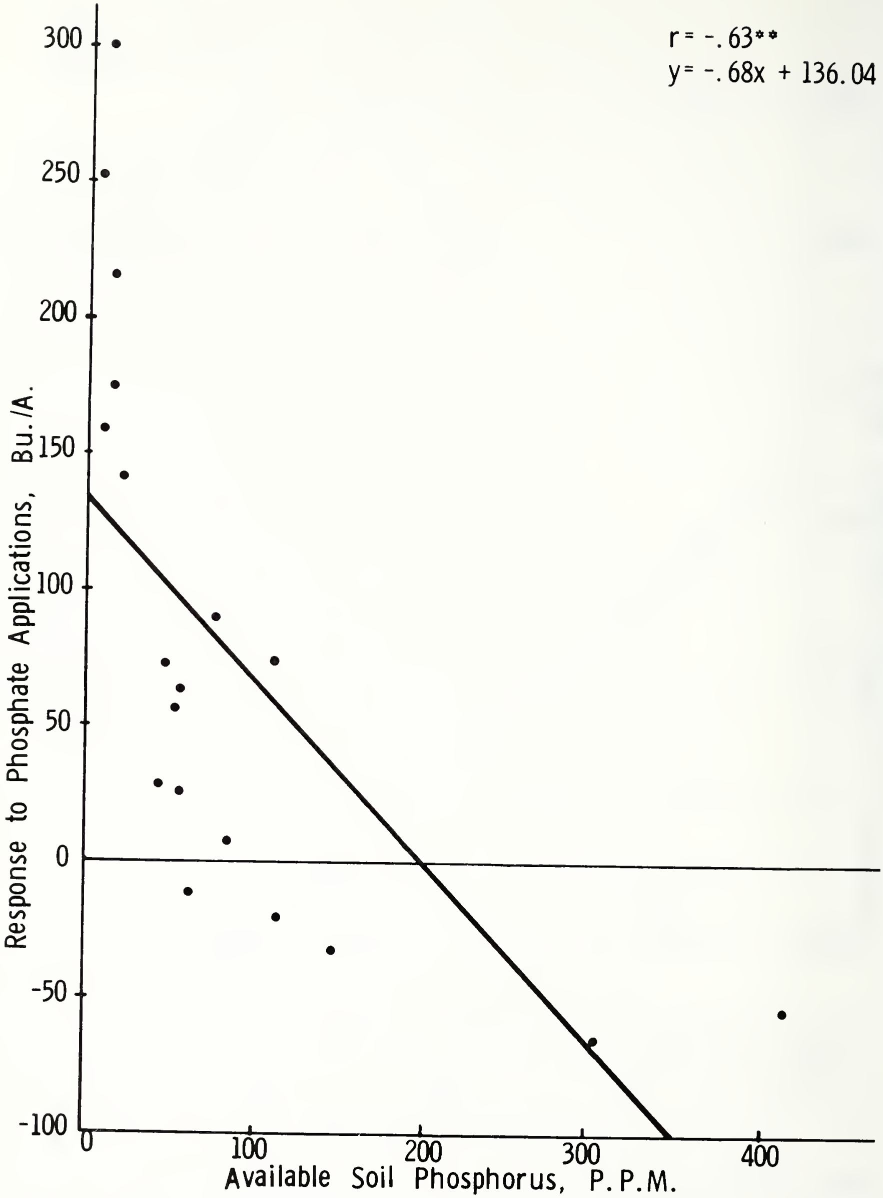

Figure 5. — The response in Number 1 roots by sweet potatoes to fertilizer phosphorus (120 pounds P_2O_5/acre) as related to the level of available soil phosphorus.

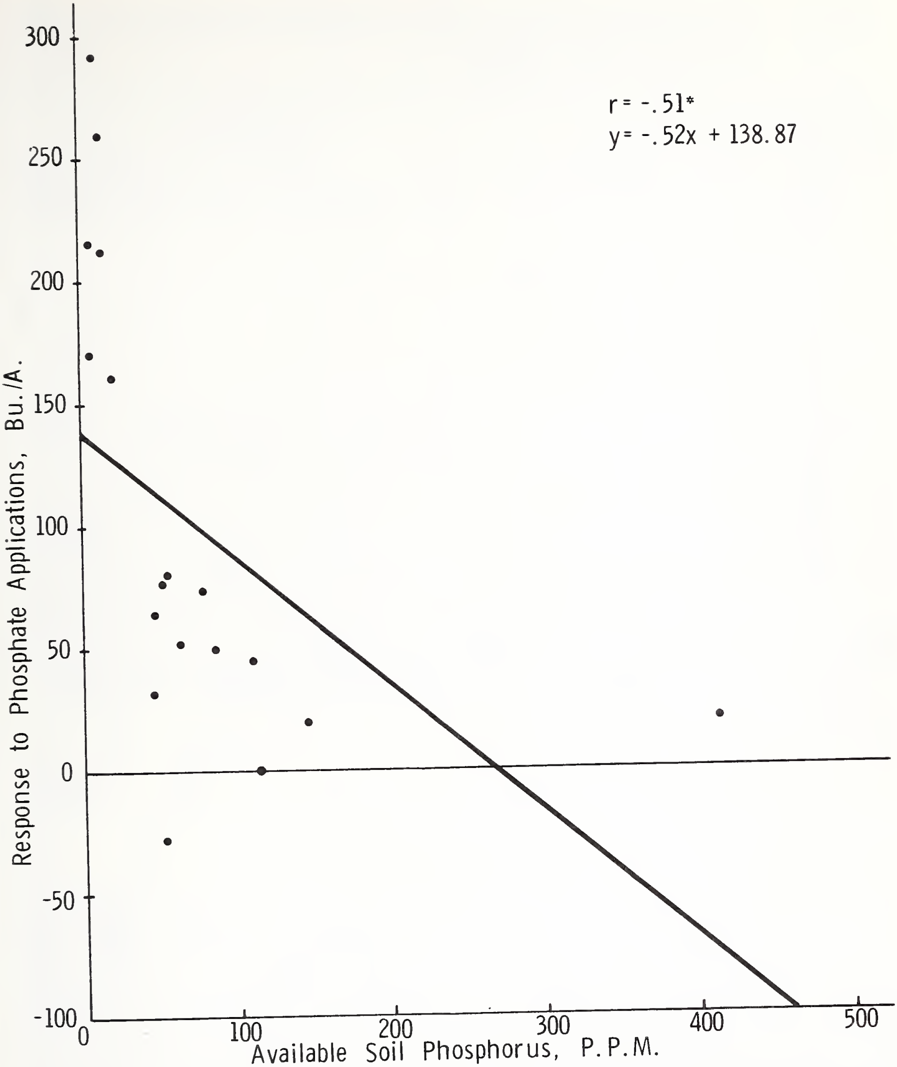

Figure 6. — The response in Number 1 roots by sweet potatoes to fertilizer phosphorus (150 pounds P_2O_5/ acre) as related to the level of available soil phosphorus.

significant r value of -0.51* indicate that there was still a true negative association.

The influence of the P application rate at various levels of soil P on the total yield by sweet potatoes at all of the sites used is shown in Table 4. In

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*The single asterisk will indicate significance at the .05 level of probability here and throughout this bulletin.

Table 4. — The total yield of sweet potatoes at each experimental location as influenced by the available* phosphorus level in the soil and the phosphorus application rate**, 1966-75

Location	Nearest Town	Date	Soil Series***	P Level in Soil	Total Yield (Bushels/Acre)						L.S.D. (.05)	L.S.D. (.01)	C.V. (%)
					P_2O_5 Application Rates								
					0	30	60	90	120	150			
1	Chase	1966	Olivier-Calhoun	52	494	585	597	574	543	587	75	NS	11.0
2	Oak Grove	1966	Loring	55	178	213	265	272	228	237	38	51	13.4
3	Clinton	1967	Loring	45	418	574	566	578	603	595	62	85	9.3
4	Chase	1967	Loring-Olivier-Calhoun	76	280	321	354	379	398	334	56	76	13.4
5	Chase	1968	Calhoun	44	401	434	433	421	438	440	NS	NS	6.6
6	Clinton	1968	Providence	10	235	478	521	540	571	595	38	52	6.4
7	Chase	1969	Granada	61	611	632	624	613	610	658	NS	NS	6.5
8	Chase	1970	Calhoun	146	529	523	559	536	546	574	NS	NS	10.0
9	Gilbert	1971	Calhoun	84	594	667	622	632	636	637	NS	NS	6.9
10	Wisner	1971	Olivier-Calloway-Calhoun	56	390	382	350	426	380	370	NS	NS	20.8
11	Clinton	1971	Olivier	14	283	414	476	486	523	529	41	56	7.6
12	Clinton	1972	Providence-Calloway	7	190	346	395	385	417	415	30	41	7.0
13	Clinton	1973	Providence	20	261	437	497	486	524	547	32	44	5.8
14	Chase	1973	Calhoun	114	507	469	517	530	473	499	NS	NS	8.3
15	Clinton	1974	Providence	14	254	465	507	530	537	539	27	36	4.7
16	Chase	1974	Calhoun	111	457	492	479	482	524	513	NS	NS	11.7
17	Clinton	1975	Providence	5	251	479	534	571	614	607	59	81	9.6
18	Baton Rouge	1975	Olivier	412	531	515	546	552	531	592	NS	NS	10.8

* Phosphorus extracted with $0.1\ N\ HCl + 0.03\ N\ NH_4F$ and expressed as ppm of air dry soil.

** In addition to the phosphorus application, each plot received 30 pounds of N and 60 pounds of K_2O per acre.

*** Each soil used was of the silt loam textural class.

C.V. = Coefficient of variation.

the first 2 years, the benefits of P application were clearly demonstrated, even on the Loring-Olivier soil at Chase with 76 ppm of P in extractable form. For the next 4 years, only the Providence soil at 10 ppm of P and the Olivier soil at 14 ppm of P showed significant responses to P additions. During the remainder of the test period, 1972 to 1975, the response to P application was limited to those soils which contained less than 100 ppm of extractable P. However, on those soils which contained from 5 to 20 ppm of extractable P the response was very marked. A somewhat greater degree of reliability of the data in this table is inferred from the relatively low coefficients of variation compared with those in Table 3 on Number 1 root production. This is usually true for the total yield of most crops, especially where grading of the products is done subjectively. Again, it is of interest that slightly over half of the test sites showed significant benefits from P applications, and most of the others indicated responses with some degree of probability at some level of application, except for the Olivier soil at Baton Rouge with 412 ppm of extractable P from which any benefit from additional phosphate appeared extremely doubtful.

The trends shown graphically in Figure 7 illustrate that the most pronounced response to phosphate applications occurred at the first 30-pound increment, especially on those soils that were relatively low in extractable P. Responses to the second increment were still quite marked in most cases even on the soils that were relatively high in extractable P. It should be noted that several of the soils did not reach maximum yields until 120 pounds of P_2O_5 were applied per acre, and this was even true for the soil

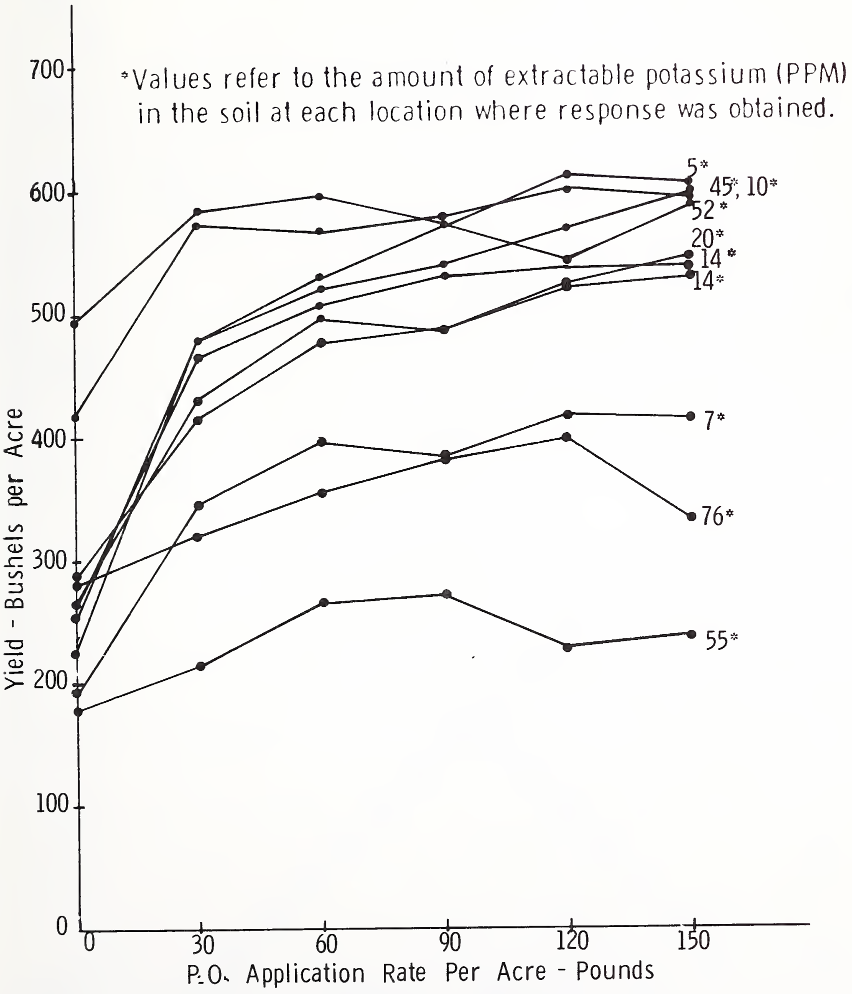


Figure 7. — The total yield of sweet potatoes at each experimental location where significant responses were obtained as influenced by the available phosphorus level in the soil and the phosphorus application rate, 1966-75.

with 76 ppm of extractable P. At least three of the soils, ranging in extractable P from 7 to 20 ppm, were still showing response to phosphate application at 150 pounds of P_2O_5 per acre.

The influence of the soil level of available P on the response in terms of total production to P applications at the 30 pounds of P_2O_5 per acre rate is shown graphically in Figure 8. In general, the soils lowest in extractable P gave the highest response to P applications and vice versa. This negative relationship is indicated by the correlation coefficient of -0.49* and the gradual down slope of the regression line. However, the moderate value of r (-0.49*) indicates that the association between these two variables is not

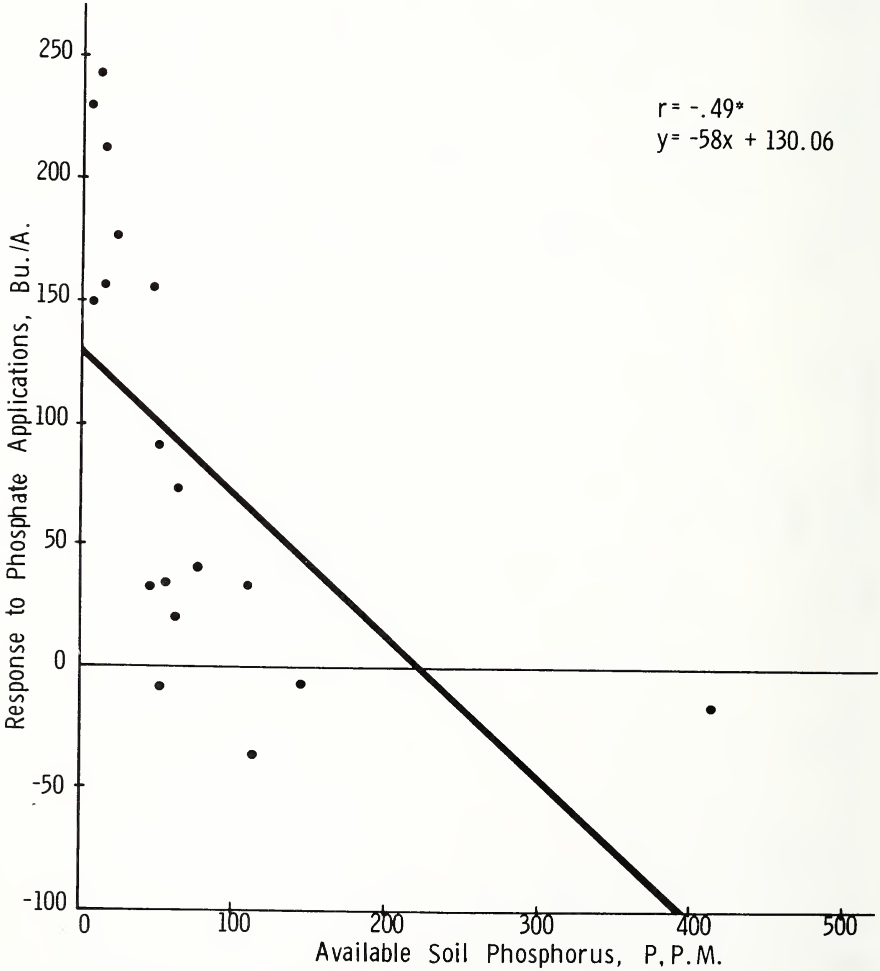


Figure 8. — The response in total production by sweet potatoes to fertilizer phosphorus (30 pounds P_2O_5/ acre) as related to the level of available soil phosphorus.

as close as would be desired and leaves some doubt as to the usefulness of the calibration.

Corresponding information presented in Figure 9 at the 60 pounds of P_2O_5 per acre rate of application also indicates that lesser responses were obtained to P applications on soils that were relatively high in extractable P. Again, the moderate negative relationship was shown by an r value of only moderate magnitude, -0.53*.

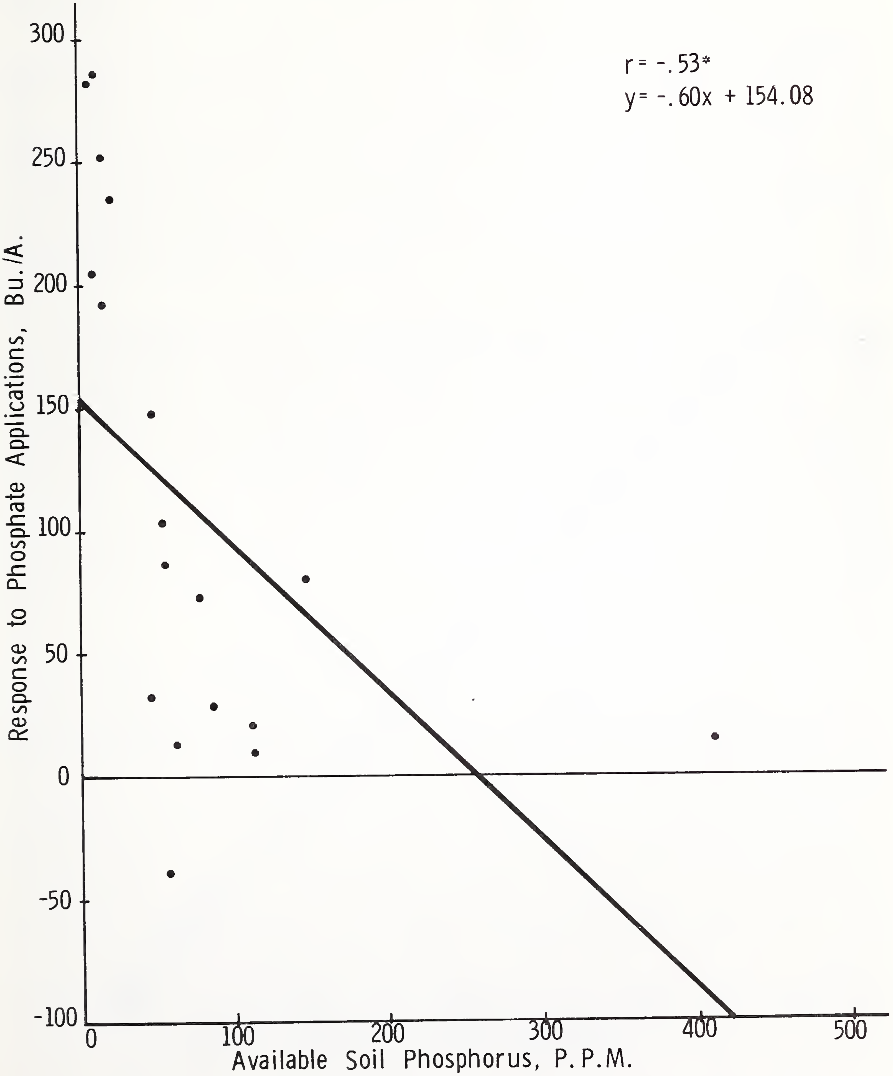


Figure 9. — The response in total production by sweet potatoes to fertilizer phosphorus (60 pounds P_2O_5/ acre) as related to the level of available soil phosphorus.

The results obtained at the 90 pounds of P_2O_5 per acre application rate were very similar to those obtained at the 60 pound rate (Figure 10). The correlation value of -0.54* is almost the same; the slope of the regression

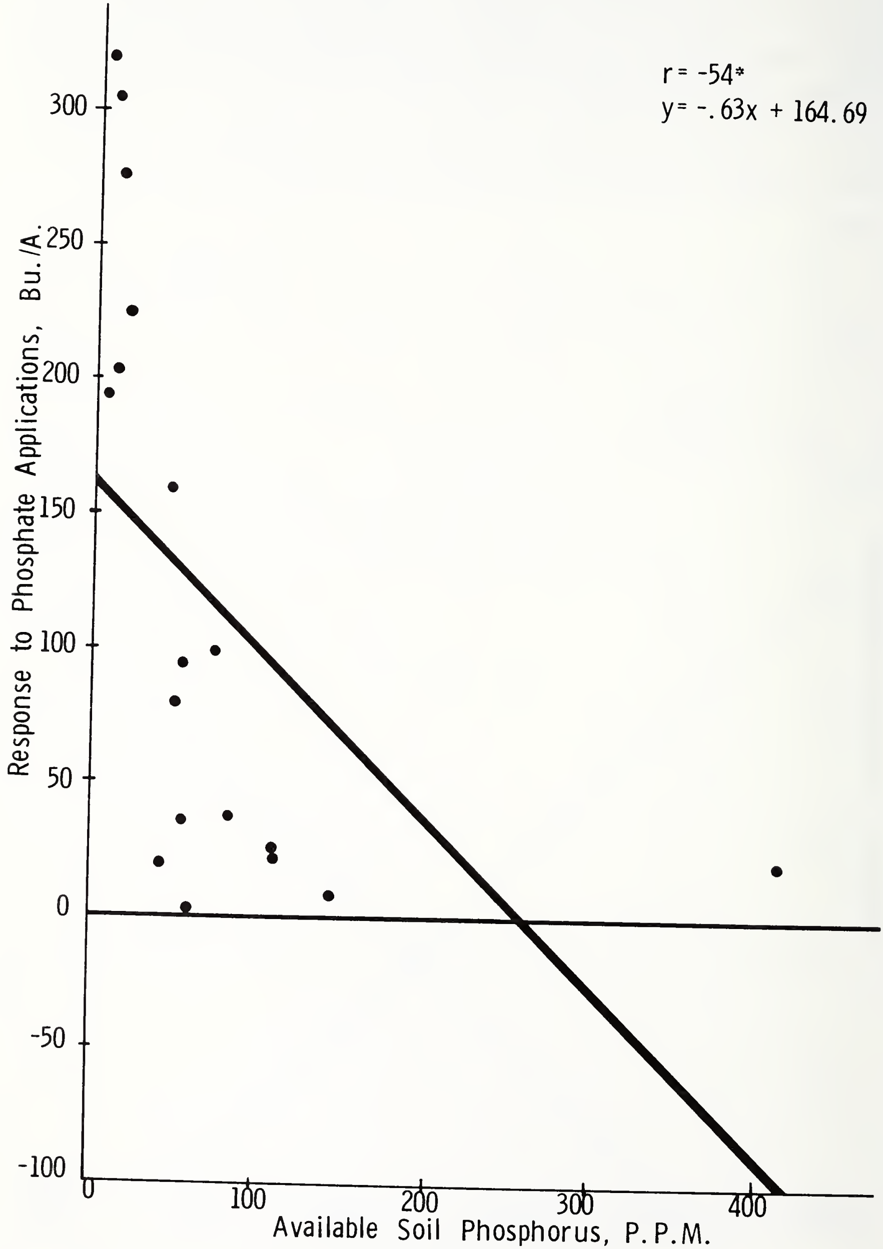


Figure 10. — The response in total production by sweet potatoes to fertilizer phosphorus (90 pounds P_2O_5/ acre) as related to the level of available soil phosphorus.

line is practically identical, and it is thus apparent that the two variables of response to phosphate application and level of soil P were not highly related but were generally related. (Each plot in the P study received 30 pounds of N and 60 pounds of K_2O per acre.)

Similar information is presented in Figure 11, in which case 120 pounds of P_2O_5 were applied per acre. The slope of the regression line is a little steeper than it was in the previous graph, but the correlation value of -0.54* did not change at all, thus still indicating only a moderate degree of association between the two variables under study.

The data on correlation of these variables at the highest rate of P application, 150 pounds of P_2O_5 per acre, are shown graphically in Figure 12. At this rate of application the regression line tends toward a lesser slope, and the correlation value is reduced to some extent to a value of -0.46*, although it remains statistically significant. This confirms the information developed in the previous graphs that the response by sweet potatoes to P applications was negatively related to the level of available soil P but only in a general way.

Figures 8 through 12, when considered together, imply that the degree of association between the response to applied phosphate and the P level in the soil depends to some extent on the rate of P that is applied. The implication is given that the balance between the three nutrients applied, N-P-K, is important in affecting the response obtained from applying P fertilizer to a soil at any level of P availability. This may be of considerable importance to those involved in correlation work of this kind where calibration charts are developed from correlating crop responses to applied nutrients with soil levels of these nutrients.

The effect of applying K at different rates to soils with various levels of extractable K on the production of Number 1 roots by sweet potatoes is shown in Table 5. During the first 2 years when all of the soils analyzed above 100 ppm of K, no response was gained to potash application at any rate. The c.v. in these tests was undesirably high. Then, beginning in 1968, significant responses to K applications were shown on the soils testing 100 ppm or less of K, except for the Olivier-Calloway soil at Wisner in 1971, in which case the c.v. was again relatively high. Following that, good responses were obtained to potash on all of the soils that contained less than 100 ppm of extractable K, except the Calhoun soil at Chase in 1973. In the latter part of the experimental period, the c.v. was somewhat smaller, indicating better control over experimental error. It is of interest that of the 18 study sites used nine showed significant responses by sweet potatoes to potash application; however, only at five of the nine were highly significant responses shown.

The type of response obtained to potash application on the different soils

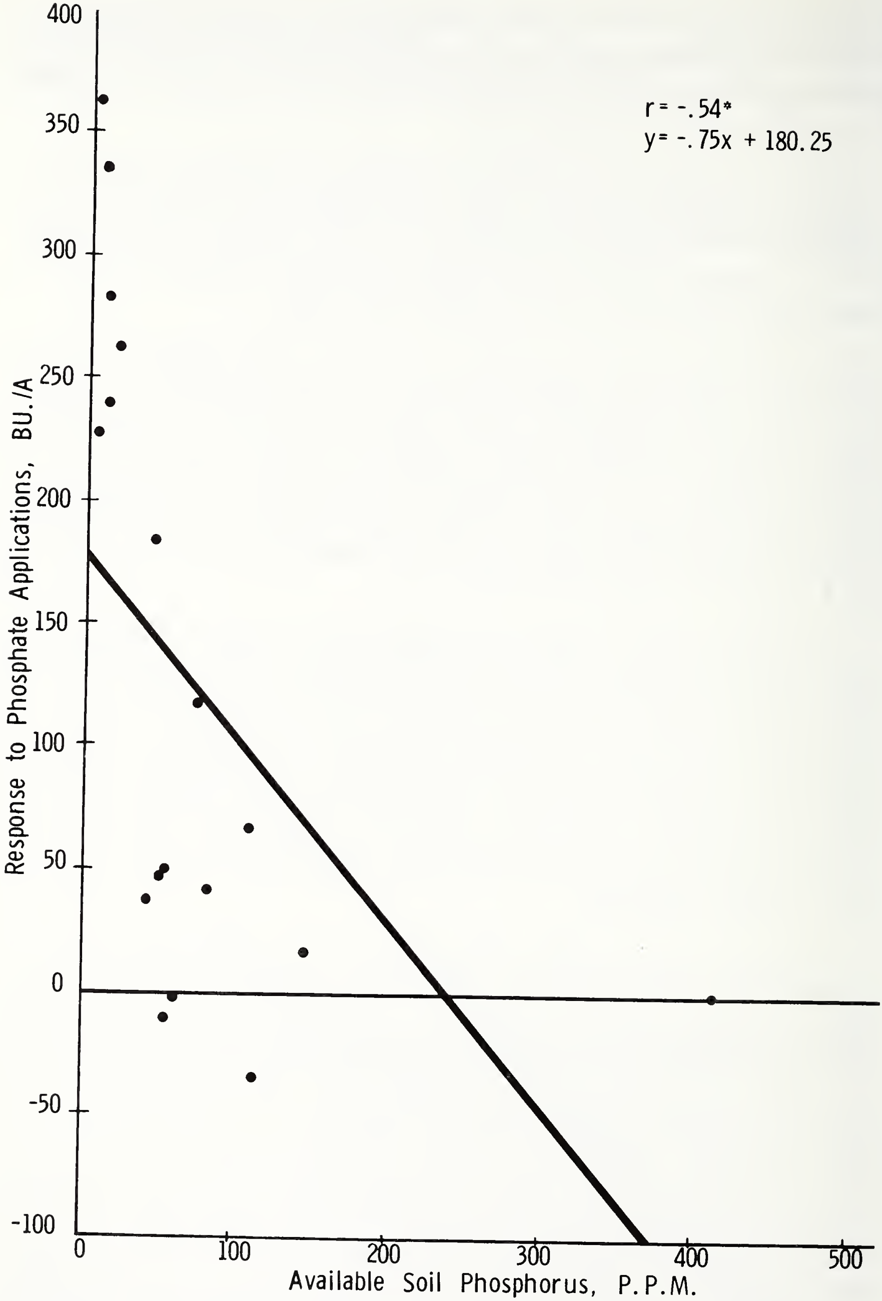


Figure 11. — The response in total production by sweet potatoes to fertilizer phosphorus (120 pounds P_2O_5/ acre) as related to the level of available soil phosphorus.

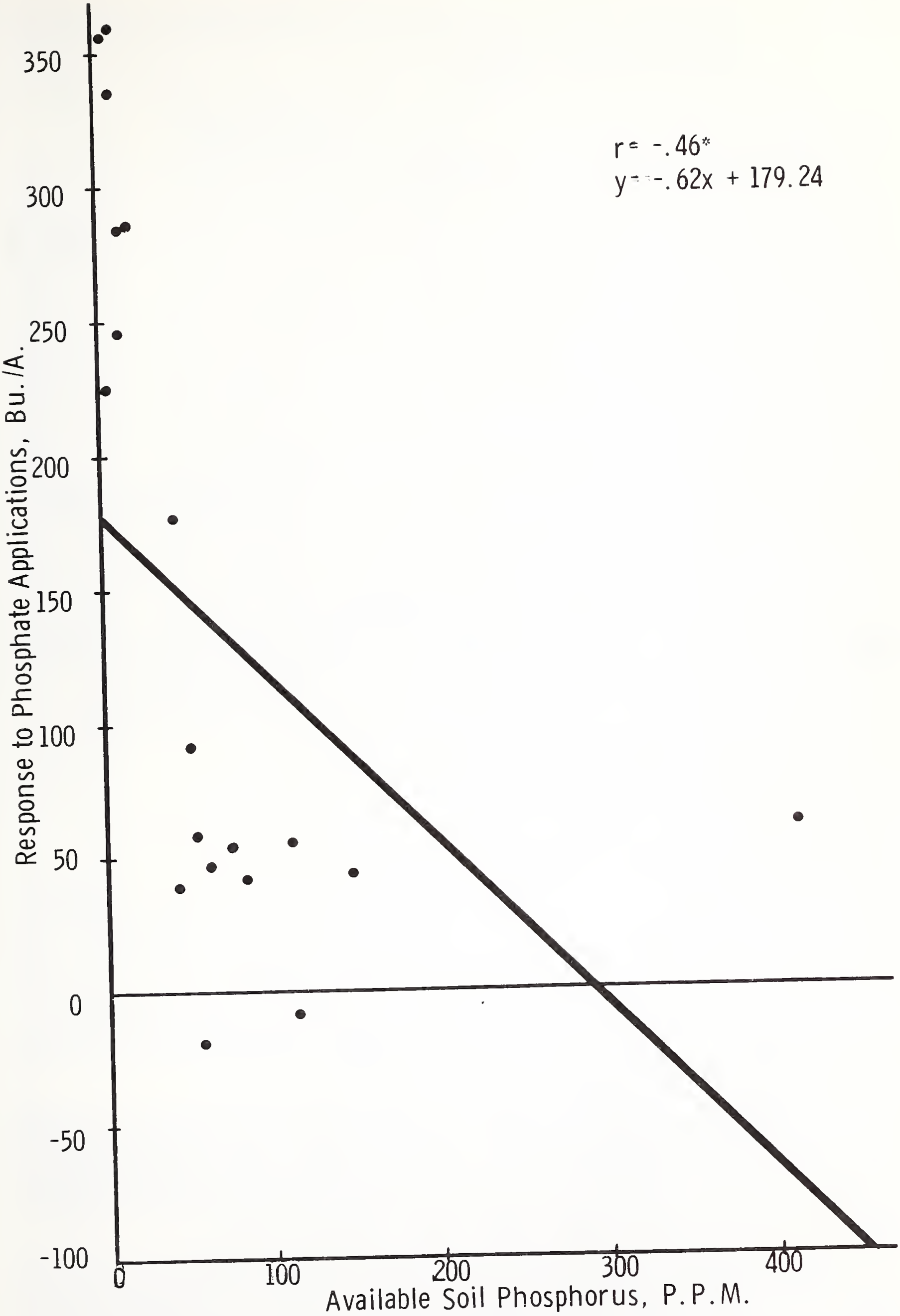


Figure 12. — The response in total production by sweet potatoes to fertilizer phosphorus (150 pounds P_2O_5/acre) as related to the level of available soil phosphorus.

Table 5. — The yield of Number 1 sweet potatoes at each experimental location as influenced by the available* potassium level in the soil and the potassium application rate**, 1966-75

					No. 1 Potatoes (Bushels/Acre)								
					K₂O Application Rates								
Location	Nearest Town	Date	Soil Series**	K Level in Soil	0	30	60	90	120	150	L.S.D. (.05)	L.S.D. (.01)	C.V. (%)
1	Chase	1966	Olivier-Calhoun	150	392	363	407	363	347	440	NS	NS	26.0
2	Oak Grove	1966	Loring	120	103	100	81	102	106	78	NS	NS	26.2
3	Clinton	1967	Loring	110	224	234	215	213	180	216	NS	NS	22.8
4	Chase	1967	Loring-Olivier-Calhoun	145	193	176	196	213	237	213	NS	NS	19.3
5	Chase	1968	Calhoun	95	272	282	321	299	311	328	28	38	7.7
6	Clinton	1968	Providence	80	232	274	269	293	270	322	50	NS	15.2
7	Chase	1969	Granada	100	388	412	433	449	460	453	44	NS	8.3
8	Chase	1970	Calhoun	200	279	327	296	322	322	290	NS	NS	17.0
9	Gilbert	1971	Calhoun	80	387	400	435	436	453	483	52	NS	10.0
10	Wisner	1971	Olivier-Calloway-Calhoun	90	224	302	289	269	254	259	NS	NS	22.6
11	Clinton	1971	Olivier	55	250	266	296	343	340	357	33	45	8.8
12	Clinton	1972	Providence-Calloway	80	208	250	269	298	286	338	42	57	12.7
13	Clinton	1973	Providence	50	139	180	209	248	250	270	37	50	14.1
14	Chase	1973	Calhoun	60	398	360	321	421	369	343	NS	NS	17.4
15	Clinton	1974	Providence	64	247	283	349	363	395	376	44	60	10.8
16	Chase	1974	Calhoun	142	290	244	346	301	290	287	NS	NS	22.6
17	Clinton	1975	Providence	87	322	411	379	385	412	404	54	NS	11.5
18	Baton Rouge	1975	Olivier	117	305	273	302	286	293	289	NS	NS	15.1

* Potassium extracted with 0.1 *N* HCl until 1971 and with neutral 1.0 *N* ammonium acetate thereafter, and is expressed as ppm of air-dry soil.

** In addition to the potassium application, each plot received 30 pounds of N and 90 pounds of P_2O_5 per acre.

*** Each soil used was of the silt loam textural class.

C.V. = Coefficient of variation.

in terms of Number 1 roots is shown graphically in Figure 13. Unlike the response to phosphate previously described, the response to potash tended toward linearity, irrespective of the soil level of extractable K. That is, the plants were no more responsive to the first 30-pound increment of potash than they were to other increments at higher rates, with some exceptions. Furthermore, the overall responses were not nearly so large as those obtained with P applications.

The influence of the soil level of available K on the response by sweet potatoes in terms of Number 1 roots to potash applications at the 30-pound rate is illustrated in Figure 14. Only a very general negative relationship is indicated between these two factors, as is shown by the low correlation value of -0.26 and the gentle slope of the regression line.

A similar degree of association between these two factors when 60 pounds of potash were applied is indicated in Figure 15. Only a casual relationship was suggested between available soil K and response to potash application as inferred from the low correlation value (-0.26) and the gentle slope of the regression line.

However, it may be seen in Figure 16 that when 90 pounds of potash

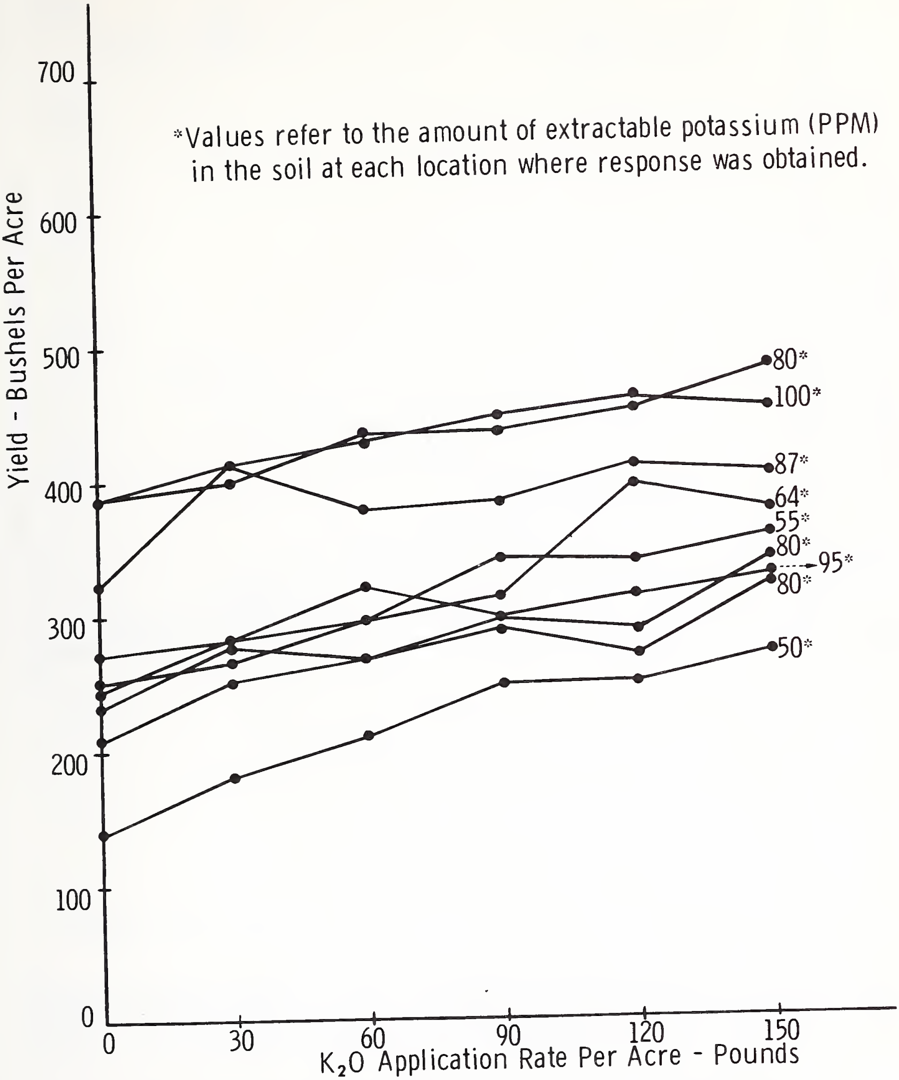


Figure 13. — The yield of Number 1 sweet potatoes at each experimental location where significant responses were obtained as influenced by the available potassium level in the soil and the potassium application rate, 1966-75.

were applied per acre, a much closer relationship between these two variables developed. The correlation value was much higher (-0.61**) than in the previous case where lesser amounts of potash were used, and the slope of the regression line became much steeper, indicating that the soil level of available K had a greater influence on the extent of response to potash applications than had been found at lower application rates. (Thirty

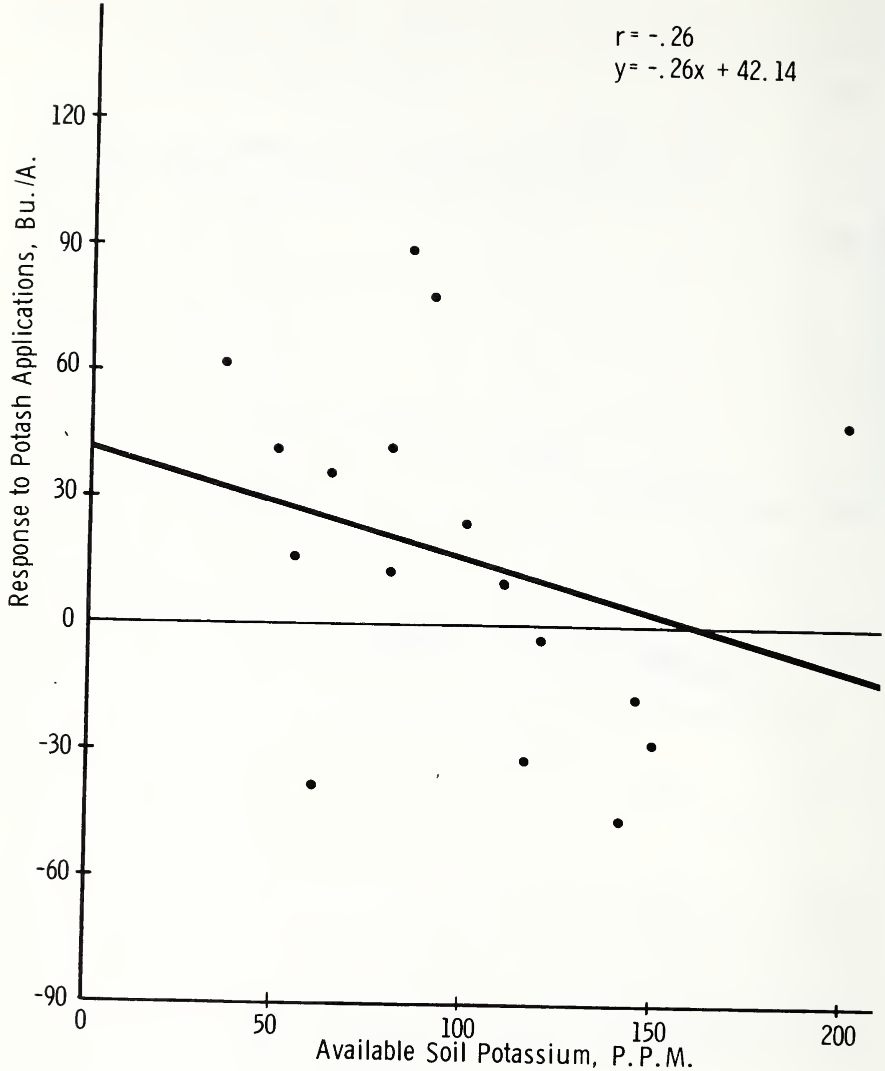


Figure 14. — The response in Number 1 roots by sweet potatoes to fertilizer potassium (30 pounds K_2O/acre) as related to the level of available soil potassium.

pounds of N and 90 pounds of P_2O_5 per acre were applied to all plots in the K experiment.)

Then, at higher potash application rates, 120 or 150 pounds of K_2O per acre, a weakening trend in the association between the variables under study was found (Figures 17 and 18). The correlation values decreased considerably to a point of insignificance (-0.41 and -0.44, respectively), and the regression line moved back toward a more horizontal position.

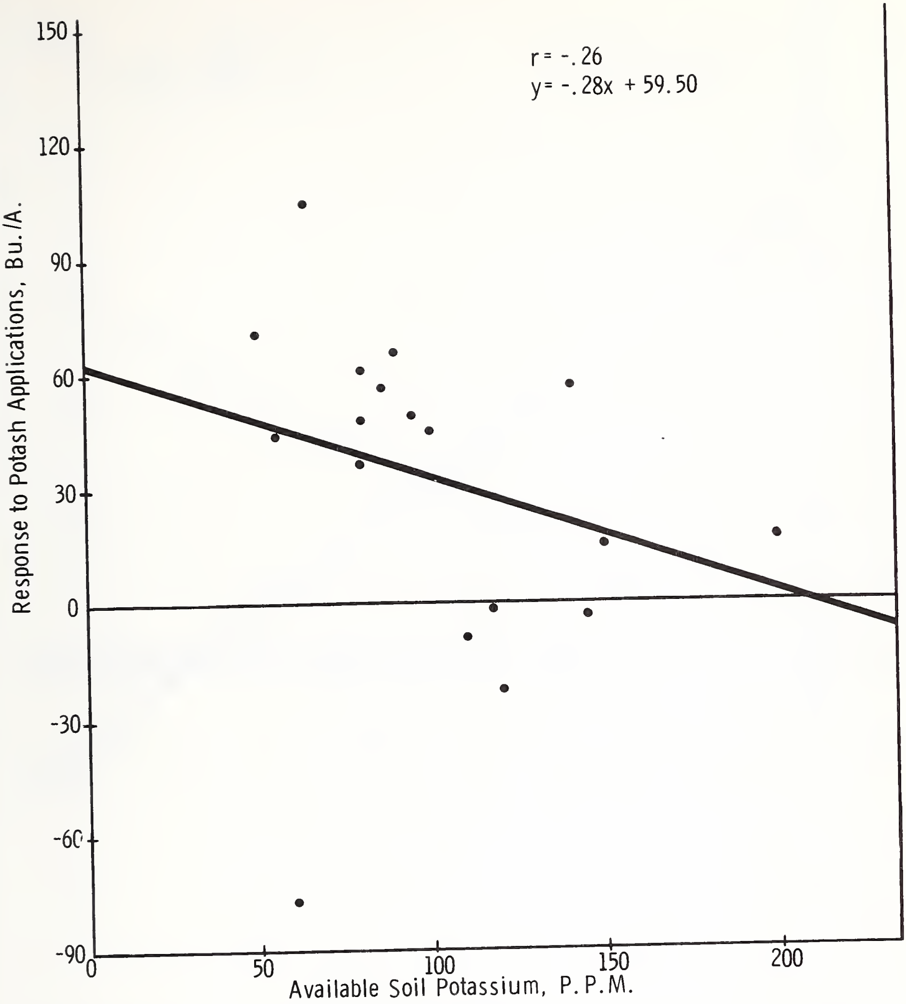


Figure 15. — The response in Number 1 roots by sweet potatoes to fertilizer potassium (60 pounds K_2O/acre) as related to the level of available soil potassium.

A most interesting point inferred here is that the degree of association between the level of available soil K and response to potash applications indicates that the balance of the major fertilizer nutrients applied was important.

The influence of K application at various rates to these soils on total production by sweet potatoes is shown in Table 6. The same soils that responded to potash in terms of Number 1 roots also showed significant increases in total yield. All of the soils that contained 100 ppm or less of

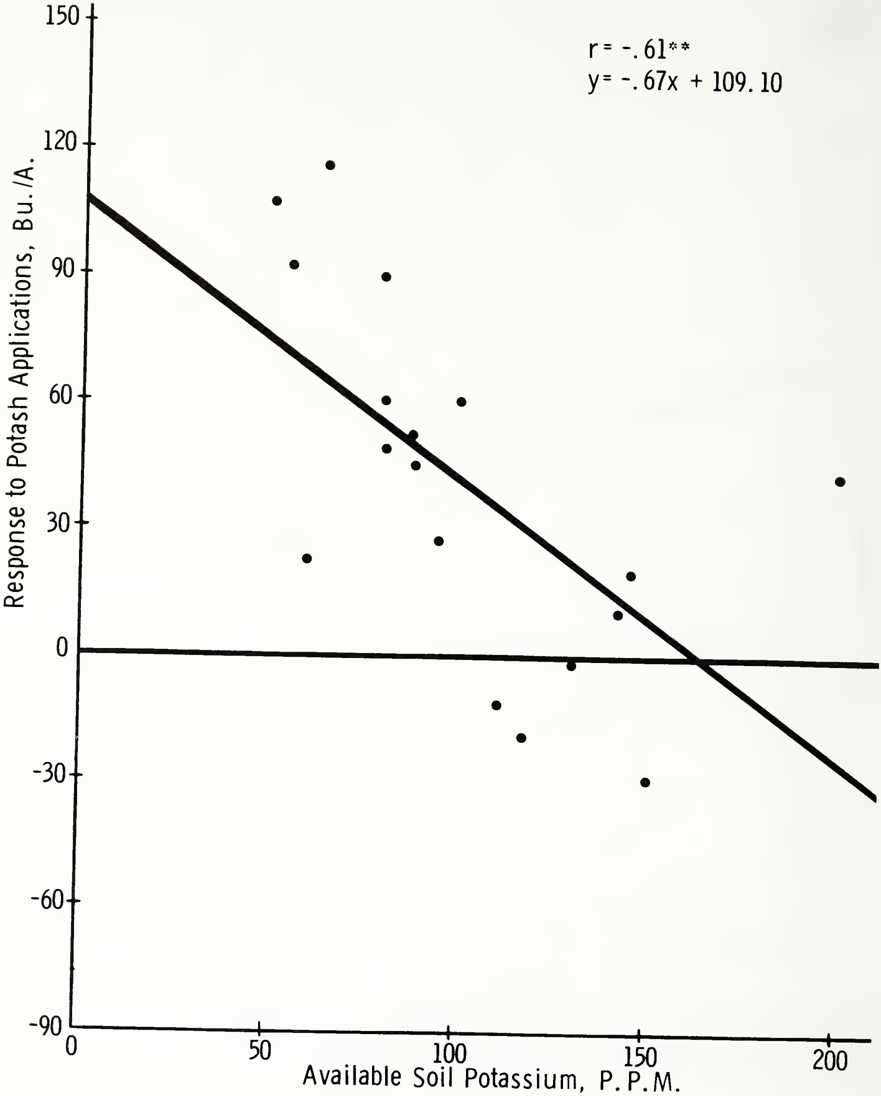


Figure 16. — The response in Number 1 roots by sweet potatoes to fertilizer potassium (90 pounds K_2O/acre) as related to the level of available soil potassium.

extractable K responded to potash use except the Olivier-Calloway soil at Wisner in 1971 and the Calhoun soil at Chase in 1973, and in these two soils some benefit from K application was indicated at some rates. The coefficients of variation for these data as a whole were much lower than the corresponding values for Number 1 roots (Table 5), indicating a greater degree of reliability of the results.

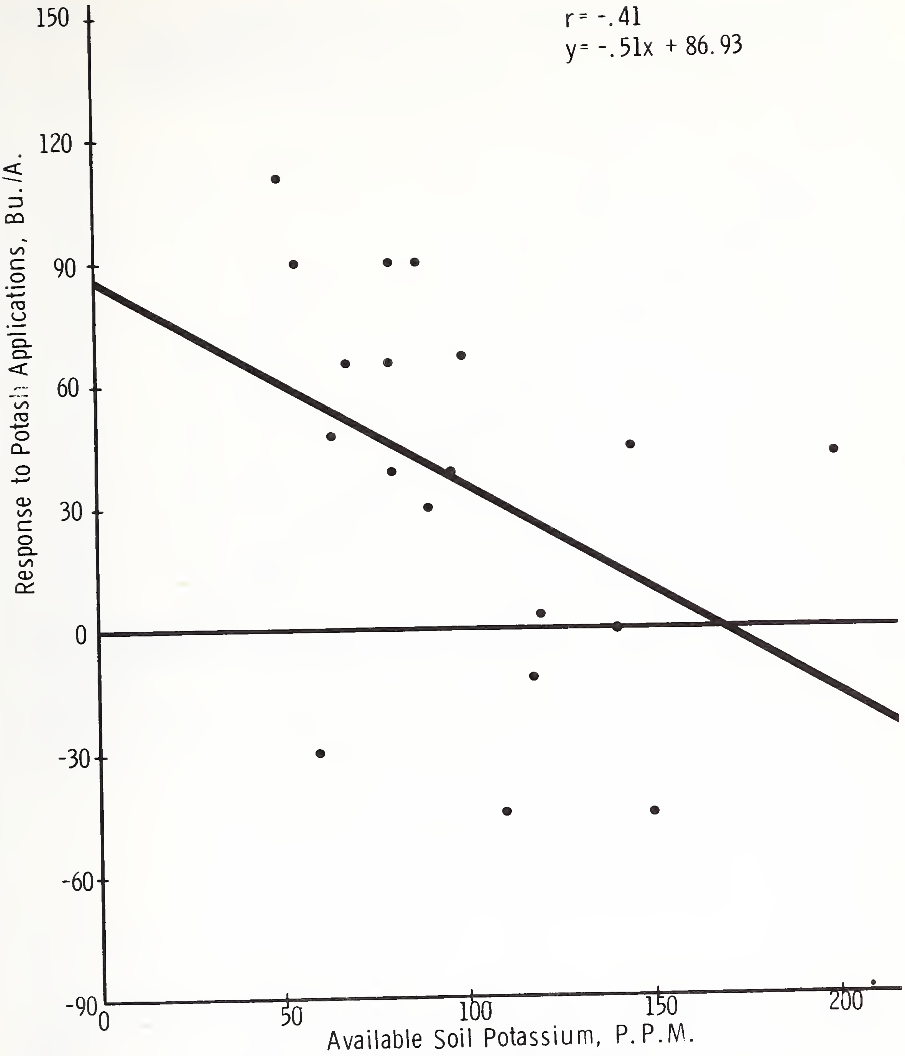


Figure 17. — The response in Number 1 roots by sweet potatoes to fertilizer potassium (120 pounds K_2O/ acre) as related to the level of available soil potassium.

The nature of the response in total yield to each increment of potash application to the soils where response was obtained is illustrated in Figure 19. The response tended to be linear, with some increases in yield at most increments of K_2O application, irrespective of the soil level of extractable K. It was interesting that the Granada soil at Chase with 100 ppm of extractable K was still showing responses at 120 pounds of K_2O applica-

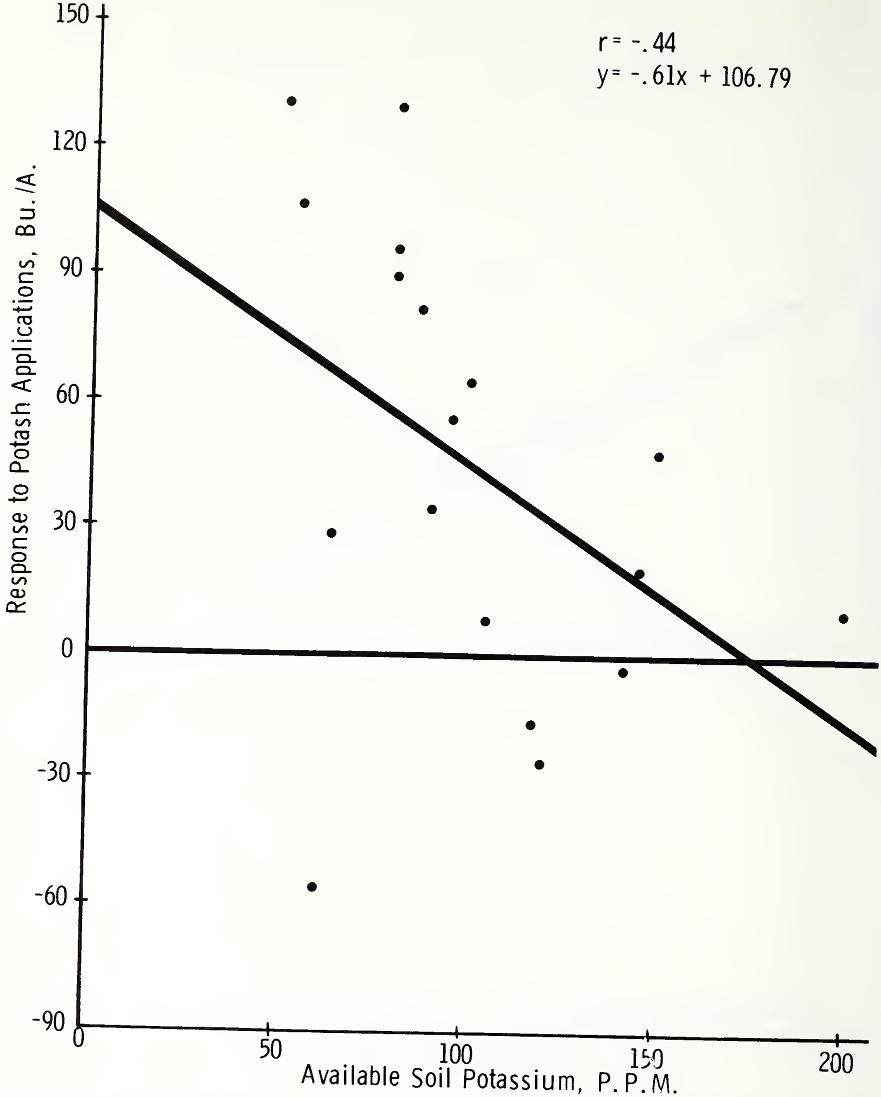


Figure 18. — The response in Number 1 roots by sweet potatoes to fertilizer potassium (150 pounds K_2O/ acre) as related to the level of available soil potassium.

tion. In addition, the Providence soil at Clinton and the Calhoun soil at Gilbert, both at 80 ppm of extractable K, continued to respond to potash use at 150 pounds per acre.

The response to potash at the 30-pound-per-acre rate in terms of total yield as influenced by the level of available soil K is illustrated in Figure

Table 6. — The total yield of sweet potatoes at each experimental location as influenced by the available* potassium level in the soil and the potassium application rate**, 1966-75

					Total Yield (Bushels/Acre)								
					K_2O Application Rates								
Location	Nearest Town	Date	Soil Series***	K Level in Soil	0	30	60	90	120	150	L.S.D. (.05)	L.S.D. (.01)	C.V. (%)
1	Chase	1966	Olivier-Calhoun	150	543	535	540	528	516	540	NS	NS	15.1
2	Oak Grove	1966	Loring	120	168	174	145	173	172	152	NS	NS	18.3
3	Clinton	1967	Loring	110	483	498	498	483	491	506	NS	NS	6.1
4	Chase	1967	Loring-Olivier-Calhoun	145	265	274	294	294	329	307	NS	NS	13.9
5	Chase	1968	Calhoun	95	377	380	417	405	428	418	23	32	4.8
6	Clinton	1968	Providence	80	431	482	497	511	521	531	29	40	4.9
7	Chase	1969	Granada	100	482	529	556	568	590	585	39	54	5.9
8	Chase	1970	Calhoun	200	446	469	475	494	495	484	NS	NS	10.7
9	Gilbert	1971	Calhoun	80	584	626	612	654	654	684	59	NS	7.7
10	Wisner	1971	Olivier-Calloway-Calhoun	90	365	412	430	403	415	395	NS	NS	13.2
11	Clinton	1971	Olivier	55	398	441	465	508	507	508	36	49	6.3
12	Clinton	1972	Providence-Calloway	80	363	423	440	456	450	485	40	54	7.6
13	Clinton	1973	Providence	50	465	492	520	552	553	549	37	50	5.8
14	Chase	1973	Calhoun	50	536	489	502	574	530	498	NS	NS	11.6
15	Clinton	1974	Providence	64	424	446	507	529	572	550	50	68	8.2
16	Chase	1974	Calhoun	142	466	456	498	475	489	472	NS	NS	13.0
17	Clinton	1975	Providence	87	472	560	543	550	575	560	56	NS	8.6
18	Baton Rouge	1975	Olivier	117	594	558	632	600	638	619	NS	NS	9.0

* Potassium extracted with 0.1 *N* HCl until 1971 and with neutral 1.0 *N* ammonium acetate thereafter, and is expressed as ppm of air-dry soil.

** In addition to the potassium application, each plot received 30 pounds of N and 90 pounds of P_2O_5 per acre.

*** Each soil used was of the silt loam textural class.

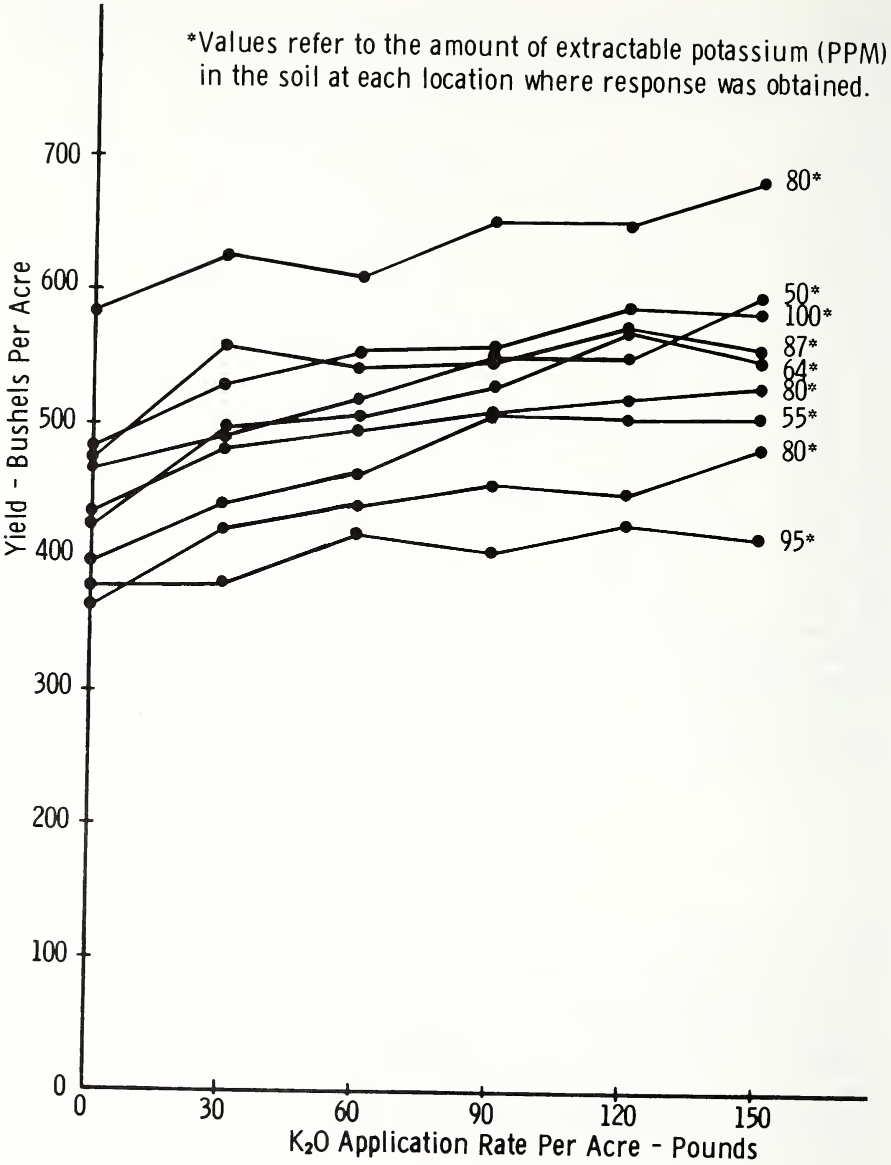
C.V. = Coefficient of variation.

20. The extent of response was not closely related to the amount of extractable K in the soil, as is verified by the low correlation value of -0.26 and the gently sloping regression line.

When 60 pounds of K_2O per acre were applied a similar picture emerged (Figure 21). The response to applied potash showed a little more dependence on the level of extractable K in the soil, but the relationship still appeared only casual with a low correlation (-0.34) and small regression values.

On the other hand, when Figure 22 is considered it is shown that a much closer relationship between the two variables is indicated when 90 pounds of K_2O per acre were applied. This is attested to by the higher correlation value of -0.62**, which is highly significant, and the sharp increase in the slope of the regression line. (It may be recalled that each plot in the K study also received 30 pounds of N and 90 pounds of P_2O_5 per acre before planting.)

When 120 pounds of K_2O were applied per acre (Figure 23) the relationship between the variables was not as close as it was at the 90-pound rate



*Values refer to the amount of extractable potassium (PPM) in the soil at each location where response was obtained.

Figure 19. — The total yield of sweet potatoes at each experimental location where significant responses were obtained as influenced by the available potassium level in the soil and the potassium application rate, 1966-75.

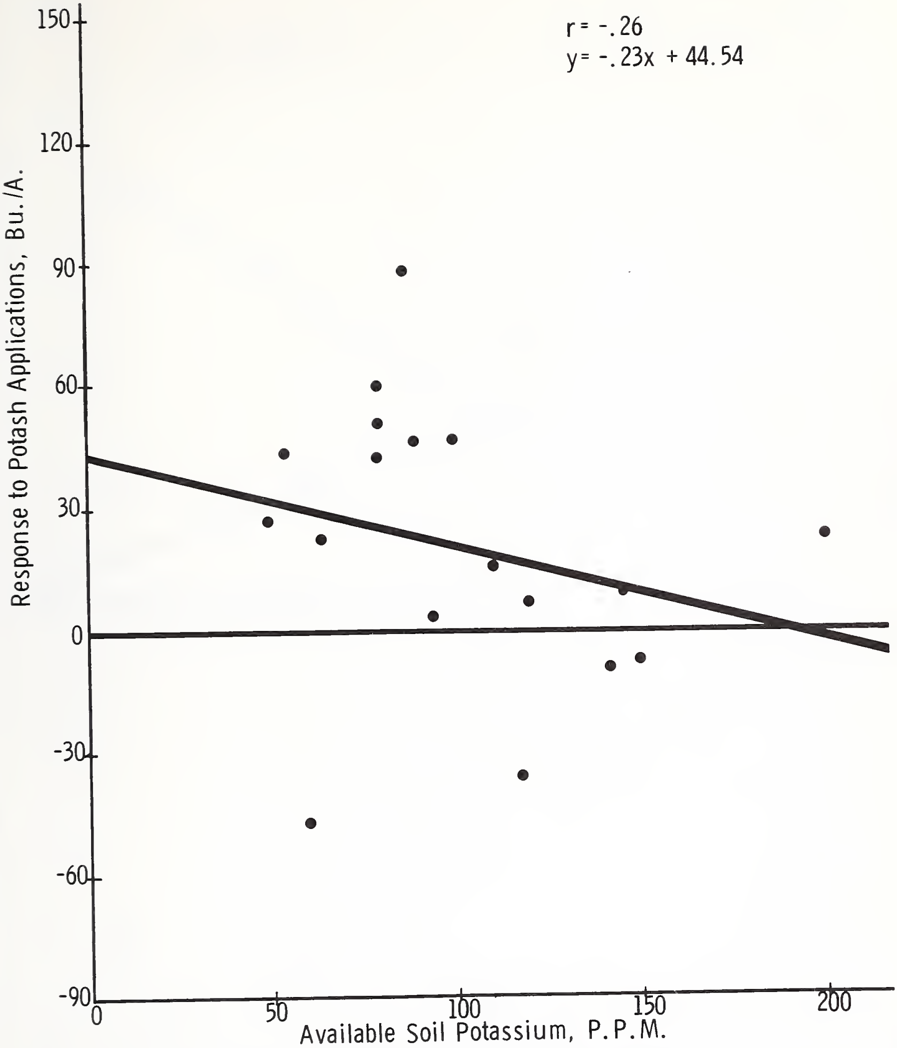


Figure 20. — The response in total production by sweet potatoes to fertilizer potassium (30 pounds K_2O/acre) as related to the level of available soil potassium.

(Figure 22), although the r value (-0.47*) was still of some significance and suggestive of some dependence of the response to potash on the level of available soil K.

With the application of 150 pounds of K_2O per acre, as presented in Figure 24, the association between the variables, although still significant (r=-0.46*), remained much below that noted when 90 pounds of K_2O were

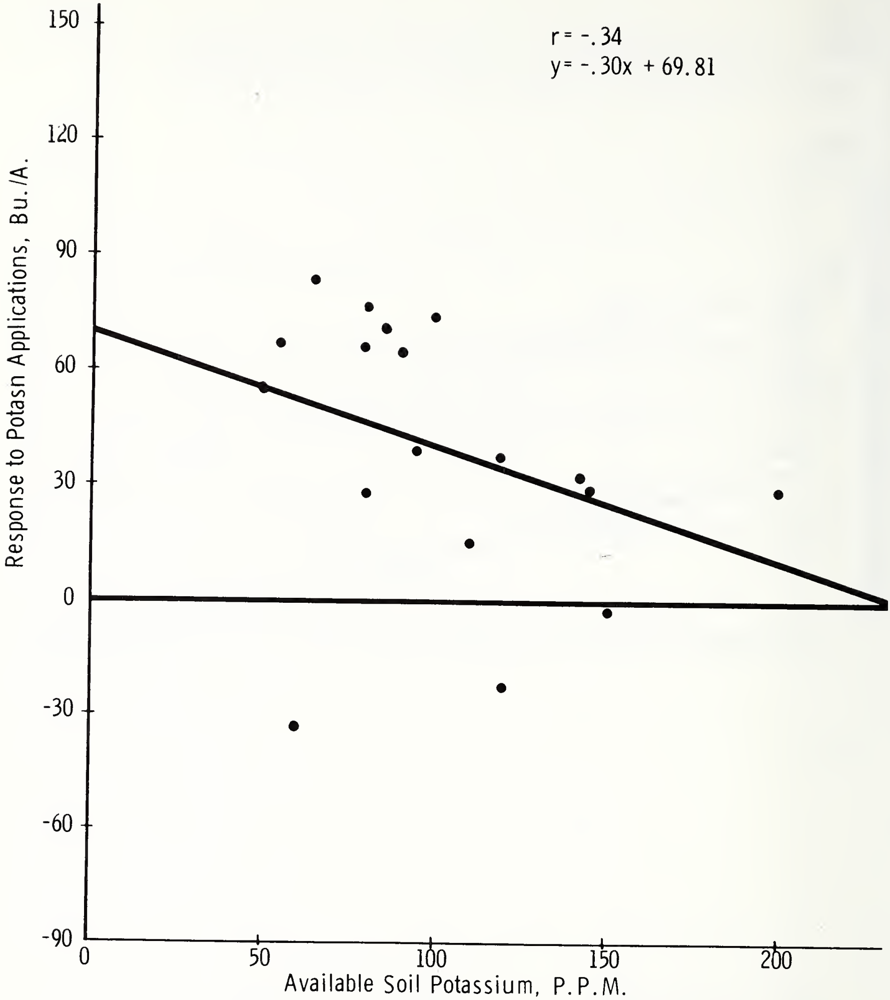


Figure 21. — The response in total production by sweet potatoes to fertilizer potassium (60 pounds K_2O/acre) as related to the level of available soil potassium.

used, indicating only a general relationship between response to potash application and the level of extractable K in the soil.

In consideration of information in Figures 20 to 24, it appears again that the degree of association of the two variables, response to potash application and level of extractable K in the soil, is strongly dependent on the rate of potash that was applied in studying the relationship. This implies further that the question of proper nutrient balance in the fertilizer may be of greater importance in such studies than had been heretofore realized.

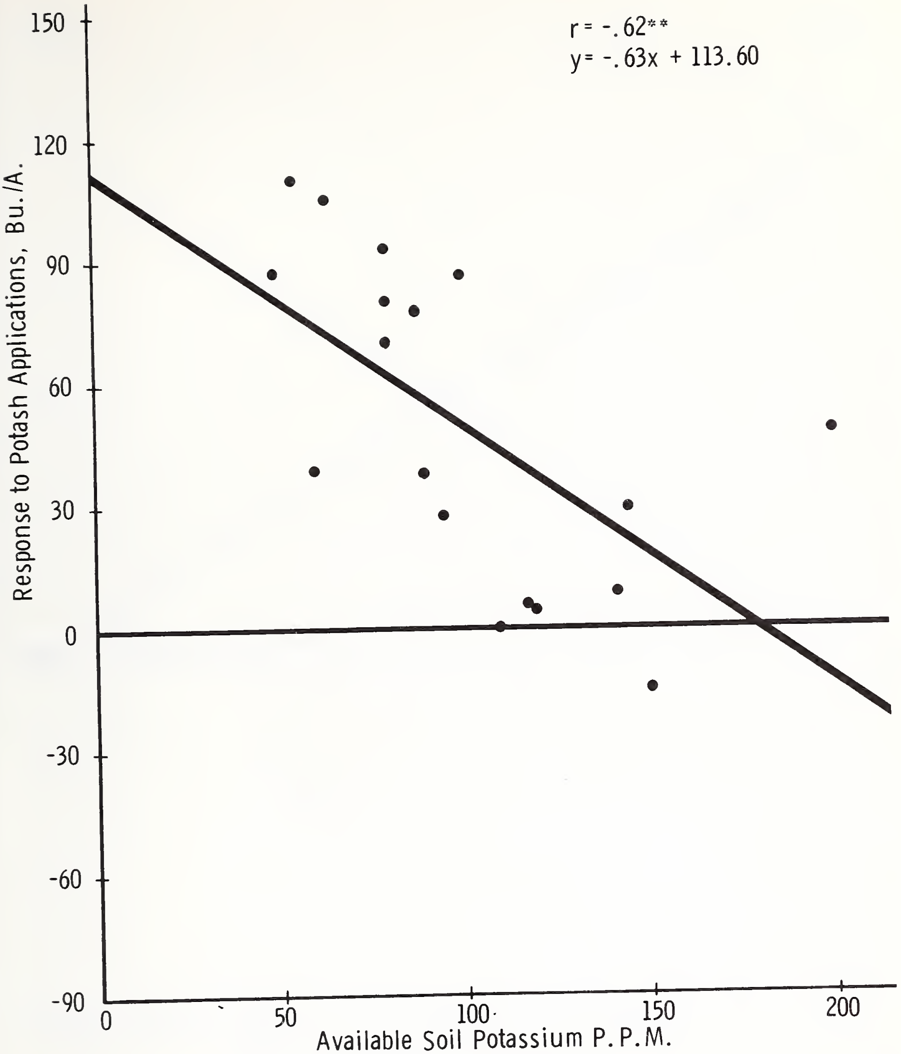


Figure 22. — The response in total production by sweet potatoes to fertilizer potassium (90 pounds K_2O/acre) as related to the level of available soil potassium.

One of the purposes of carrying on a soil analysis program is to develop an extractant that will simulate closely the absorptive capacity of plant roots in taking up plant nutrients from a given soil. It is logical to assume that different plant species have different capacities for absorbing nutrients from the same soil in view of their wide variation in root penetration into the soil and degree of development and branching within a given soil

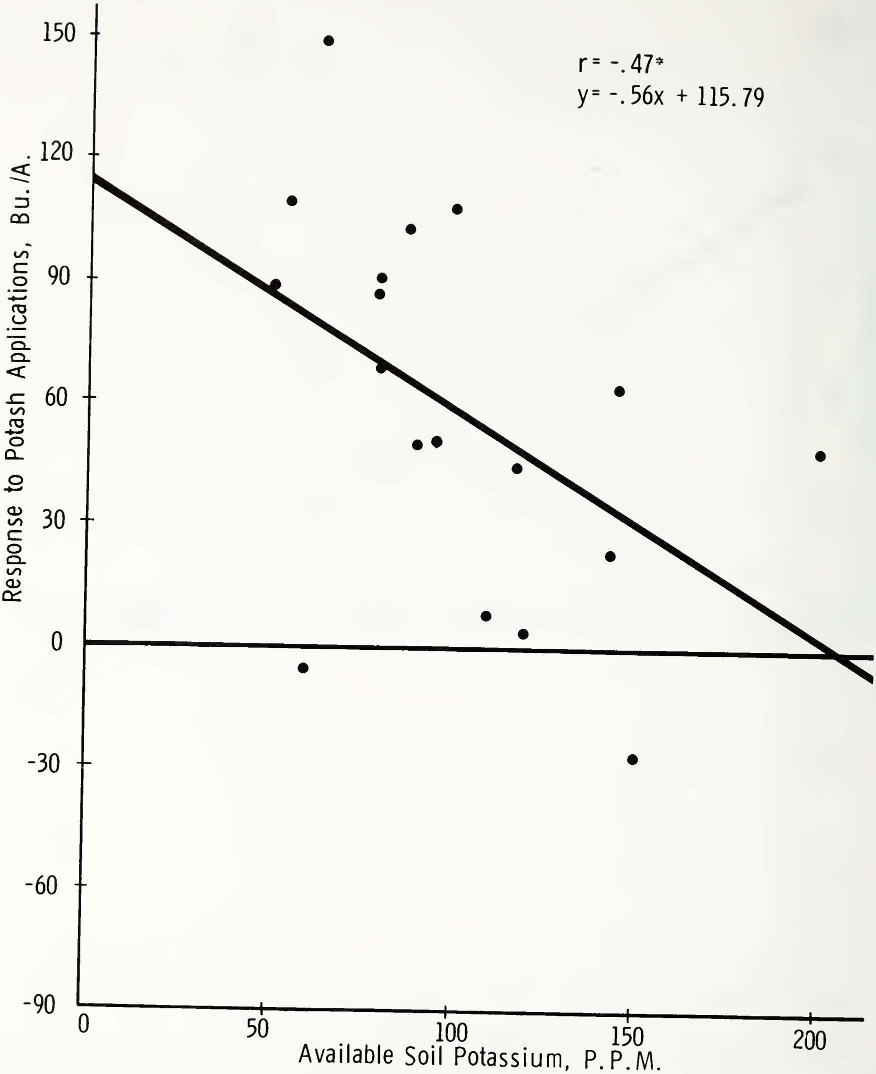


Figure 23. — The response in total production by sweet potatoes to fertilizer potassium (120 pounds K_2O/acre) as related to the level of available soil potassium.

volume. In addition, it is very likely that the biochemical efficiency with which plant roots take up nutrients from the soil varies considerably with plant species. Because of these factors, it becomes necessary to investigate the degree to which the extracting solution used in soil analysis is simulating the absorptive ability of each crop plant species, if the results of soil analysis are to be used as a tool for predicting responses to applied plant

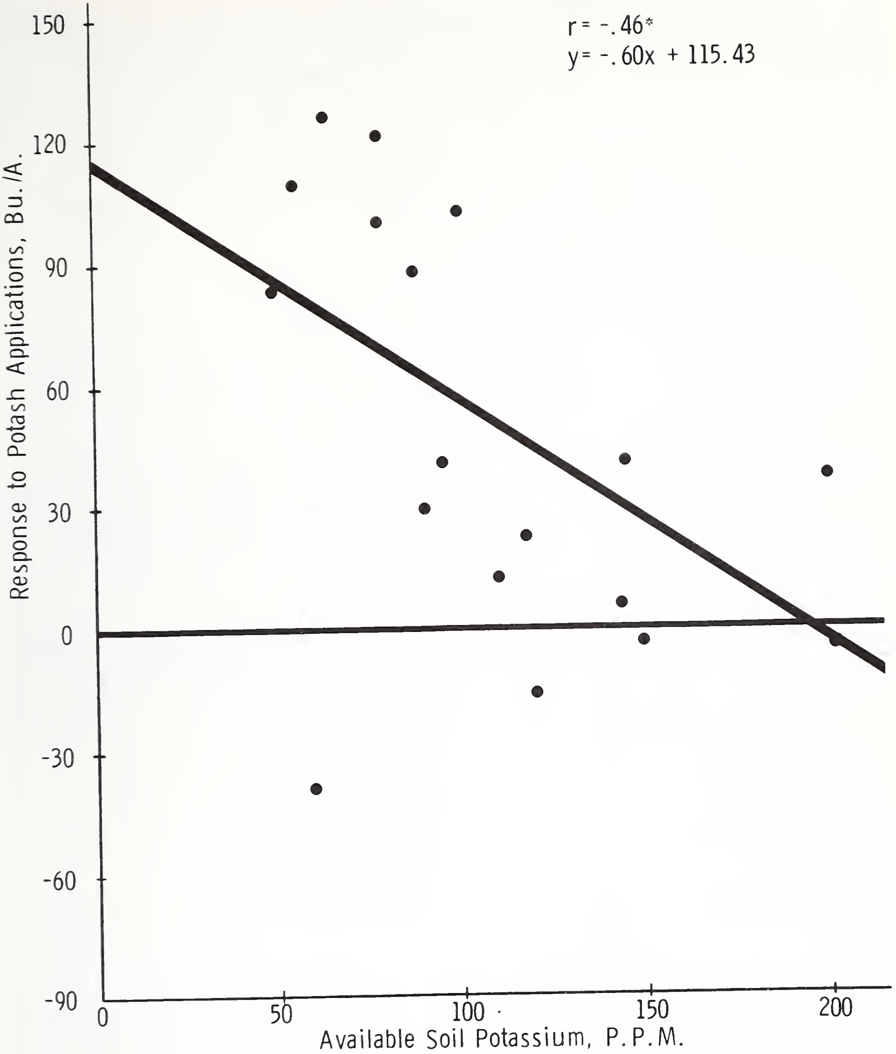


Figure 24. — The response in total production by sweet potatoes to fertilizer potassium (150 pounds K_2O/acre) as related to the level of available soil potassium.

nutrients in the future.

One way to investigate the appropriateness of the extracting solution used in soil analysis is to conduct response tests with a given crop and individual nutrients applied to similar soils which have been subjected to analysis, using the particular extracting solution under study. In this manner, after a series of experiments has been conducted, an attempt can be made to correlate the response to the applied nutrient with the level of the nutrient in the soil before fertilization. If a high correlation is developed it implies that the extracting solution is closely simulating the capacity of the crop being studied for taking up that particular nutrient from the soil. This information may be accumulated along with that from similar experiments on different crops and different soils, and calibration charts may be formulated from which predictions may be made with reasonable accuracy on the response that may be expected from applying a nutrient as fertilizer to a given soil.

The information presented in this bulletin indicates that in the case of P application to the soils used in this study, the procedures of soil analysis as presently used by the Soil Testing Laboratory at Louisiana State University, Baton Rouge *(3)* can be used to test soils to be used for the production of sweet potatoes, and the predictions of responses to P fertilization in the light of results from these soil tests can be made with some degree of confidence. However, it was hoped that closer agreement could be found between the P status of the soil as indicated by these methods *(3)* and the response by sweet potatoes to phosphate applications, such as that found by Peterson et al. with rice *(18)*.

It appears in this study that the degree of association of these two factors depended to some extent on the rate of P that was applied along with 30 pounds of N and 60 pounds of potash. If this is true generally, it implies that the balance of the major fertilizer nutrients is somewhat influential on the relationship under study. In this work, the correlation was highest when moderate rates of P (60 to 120 pounds of P_2O_5 per acre) were used along with a rate of N and K considered to be ample under the conditions of this test. This was true even though the medium rates of phosphate did not always produce the highest yield; in fact, in several cases, the highest rate of application gave the highest yield. These results imply that in studying soil-plant relationships an important point to consider in arranging the test is to insure that plant nutrients are applied in a balanced ratio insofar as possible, so that more true, near-normal responses may be obtained and measured. An exception to this generalization may be in order when the soil is known to be very low in available P, in which case a ratio somewhat unbalanced in favor of high P content may be preferable. Actually, probably the best way is to apply P at several rates at each experimental location.

The results of the work being reported here indicate also that the procedures of soil analysis as modified to include ammonium acetate instead of HCl as the cation extractant *(3)* may be of considerable value in predicting sweet potato yield responses to K applications, as was shown for rice by Peterson et al. *(18)*.

The relationship between the response to potash and the soil level of available K was found to be generally linear on the soils used in this study.

However, the discovery of this relationship, both from the standpoint of Number 1 root production and total yield, lies in the fact that potash was applied at different rates at each location along with 30 pounds of N and 90 pounds of P_2O_5 per acre. At the lower rates and also at the higher rates of potash application, only a general association between the response to potash and the soil level of available K was shown. Conversely, when a medium rate of potash was applied (90 pounds of K_2O per acre) the relationship between these two factors was much closer and became highly significant. This was true even though in some cases the highest yield was obtained at the higher rates of potash application. Again, as was the case with P, the implication is that the strength of the relationship between these variables depends largely on the rate of potash application, along with the 30 pounds of N and 90 pounds of P_2O_5 per acre which all plots in this test received.

The relationship developed more smoothly and to a higher degree between the variables when a complete fertilizer better balanced nutritionally was applied before planting. If this implication is true for K in a general way, perhaps more attention should be given to the rate of application of K in studies of this kind. Possibly in some cases different conclusions may be drawn in place of those inferred when only one or a few rates of potash application are chosen arbitrarily. Again, as was the case with P, it may be preferable to use several rates of potash application at each experimental location.

Summary

In experiments conducted on Mississippi River Terrace and Loessial Hill soils, it was found that the level of extractable P in the soil had some influence on the response by sweet potatoes to P applications, both in terms of Number 1 root production and total yield. The degree of expression of the relationship between the response to phosphate and the level of soil P was affected somewhat by the rate of application of P used in the study. Most of the soils that showed responses to phosphate contained less than 100 ppm of P before fertilization (all plots received 30 pounds of N and 60 pounds of K_2O per acre), and some of the soils, especially those with relatively low levels of P, responded to as much as 150 pounds of P_2O_5 per acre. The response to P applications tended to be curvilinear.

In contiguous studies carried on simultaneously with K, it was shown that the soil level of extractable K was fairly closely related to the response obtained from potash applications when 90 pounds of K_2O per acre were applied. However, whenever lesser or greater amounts of potash were used along with the 30 pounds of N and 90 pounds of P_2O_5 that were used on all plots, the strength of the relationship between the two variables under study was notably reduced. The soils that showed response to potash contained no more than 100 ppm of extractable K, and a few of them were still showing benefit from potash applications at the 150-pound-per-acre rate. The response to K applications appeared to be linear.

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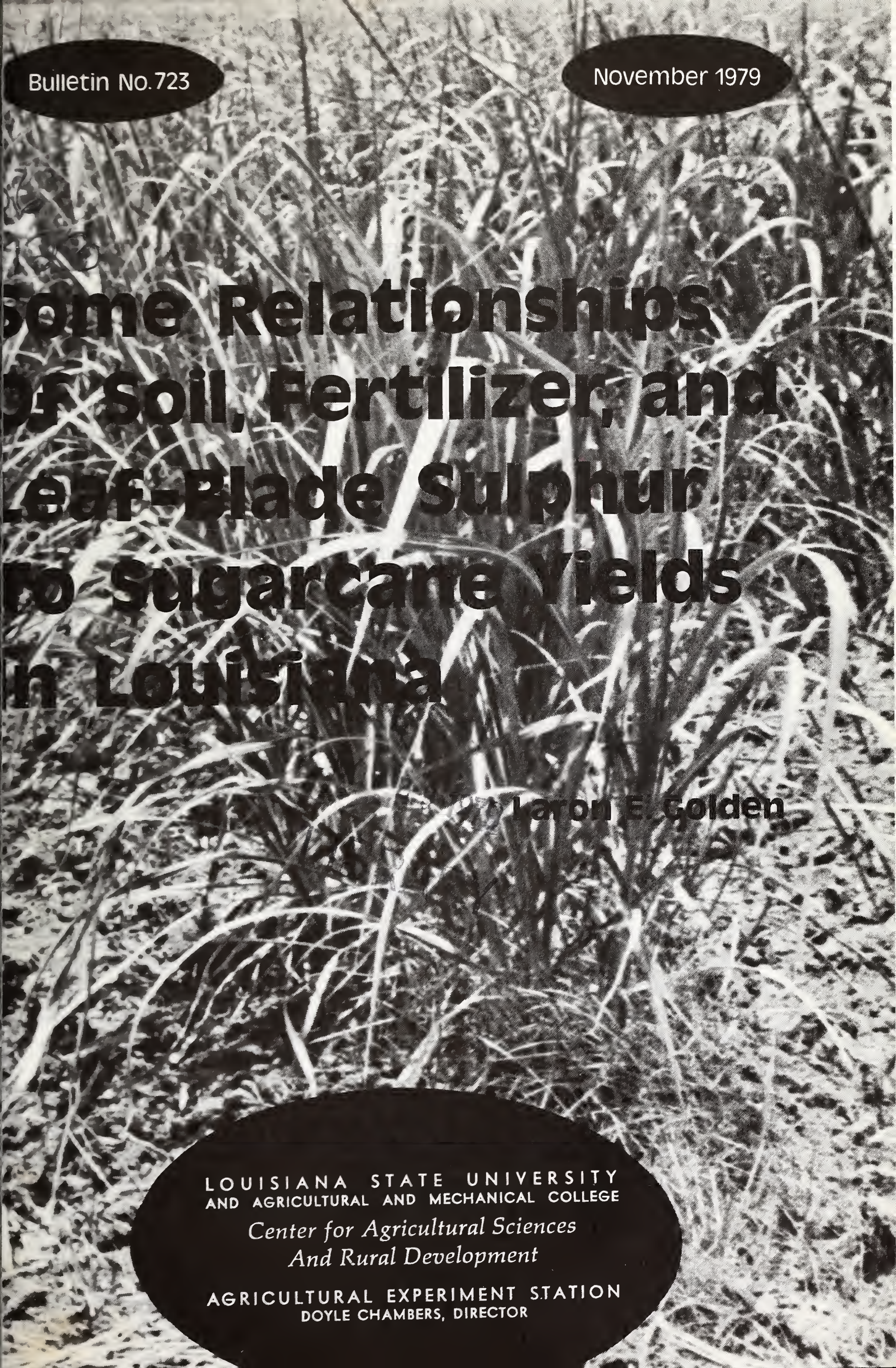

Bulletin No. 723

November 1979

Some Relationships of Soil, Fertilizer, and Leaf-Blade Sulphur to Sugarcane Yields n Louisiana

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Some Relationships of Soil, Fertilizer, And Leaf-Blade Sulphur to Sugarcane Yields in Louisiana

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Introduction

Application of normal superphosphate during a 20-year period beginning in 1946 generally resulted in sugarcane yield increases throughout the sugarcane producing area of Louisiana (*6, 7, 8, 10, 14, 16, 21, 26*[2]). Rates of phosphorus (P) as normal superphosphate were equivalent to 25 to 40 pounds of P_2O_5 per acre and rates of sulphur (S) were 15 to 24 pounds per acre. Yield increases were usually greater from stubble cane than from plant cane. They were usually greater from cane grown on fine-textured (heavy) soils, where root development in the subsoil was restricted *(20)*, than from cane on coarse-textured (light) soils. The value that may have been derived from S in normal superphosphate has rarely been considered during the 20-year period since normal superphosphate was applied primarily as a source of P.

Initial analytical work during 1963-65 led to experimental field applications of fertilizer S, beginning in 1966, from sources independent of P. In the initial work with stubble cane, results from analysis of leaf blades showed S contents that were considered to be low. Where P and S were applied separately, as well as where they were applied together, the uptake of S was substantially greater than the uptake of P *(11)*.

The primary objective of this study was to determine the effect of annually applied fertilizer S on sugarcane yields. To better understand yield data and to establish calibration curves, information was also obtained concerning S in soils and in leaf blades from check and from treated areas. The uptake of fertilizer P and fertilizer S by sugarcane and the movement of P and S in soil were studied in selected tests by use of the radioisotopes ^{32}P and ^{35}S.

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[2] Italic numbers in parentheses refer to Literature Cited, page 21.

Review of Literature

Sulphur deficiency in sugarcane has been reported in the United States *(10, 11, 12),* Puerto Rico *(3),* Australia *(24),* India *(9),* Rhodesia *(17),* and Kenya *(18).* In the United States, S deficiencies have been reported on crops in 31 of 50 states *(19, 25).*

Gosnell and Long *(17)* reported large increases in yields of sugarcane in Rhodesia due to applications of S as elemental S, as gypsum, and as magnesium sulphate. They noted that S deficiency symptoms were similar to those of nitrogen (N) deficiency. The symptoms were a general yellowish appearance of foliage, especially the young leaves, and a reduction in leaf size, tillering, and plant height.

In Louisiana, correlations between S extractable from soils by the method of Bardsley and Lancaster *(2)* and yield response to normal superphosphate were not significant. Correlations between P extractable from soils by various methods and yield response to normal superphosphate, although significant in some instances, were generally low *(14).*

During recent years in Louisiana, 20 P x S tests were conducted with stubble cane grown on medium-fine to fine-textured soils *(10).* The rate of P, as treble superphosphate, was equivalent to 40 pounds of P_2O_5 per acre, and the rate of S, as agricultural gypsum, was 24 pounds per acre. Generally, increases in yield were obtained from use of fertilizer P and from use of fertilizer S. The increases from each varied from about 4 percent to 7 percent. The increases from P and S when applied together were additive and varied from about 8 percent to 14 percent. Correlations between P extractable from the soil and yield response to P, and between extractable S and yield response to S, were low. The correlations were low due to increases in yield and age classes of cane being relatively constant, and due to the relatively narrow ranges of extractable P and S values that were generally associated with medium-fine to fine-textured soils.

Application of filter-press mud to soils in Louisiana has generally resulted in increases in S extractable from soils and increases in leaf-blade S contents of sugarcane *(10).* Recent work in Louisiana with by-product gypsum applied to sugarcane indicated a strong need for S by sugarcane grown on Baldwin silty clay loam *(10).* Results from the test with plant, first stubble, and second stubble cane during 1976-78 showed a total yield increase of 9.75 standard tons of cane per acre due to application of 1 ton of by-product gypsum (260 pounds of S) per acre to fallow land in 1975.

Materials and Methods

Treatments, Soil and Leaf Samples, and Experimental Design

During the 13-year period, 1966-1978, soil and leaf-blade samples and yield data were obtained from 38 experiments or tests with sugarcane in production areas in the vicinity of the Mississippi River, Bayou Lafourche, and Bayou Teche. The S was applied in the sulphate form at the rate of 24 pounds per acre, except at Uncle Sam Plantation where it was applied in the elemental form at the rate of 500 pounds per acre. Of the 500 pounds of S in elemental form, 9.2 percent was sufficiently fine to pass through U.S. Standard Sieve No. 140 (.105mm).

The source of sulphate S was agricultural gypsum, except in two tests at Laurel Grove Plantation where S was applied as ammonium sulphate in 1967 and 1968.

Fertilizer N was applied at a constant rate in each test. Generally, N rates were 120 pounds per acre in plant cane and 160 pounds per acre in stubble cane. When needed, fertilizer P (from an S-free source) and potassium (K) were applied at constant rates equivalent to 40 pounds of P_2O_5 and 80 pounds of K_2O per acre, respectively.

With the exception of elemental S, which was applied broadcast in April, all fertilizer materials were applied in the off-bar furrow, normally in April, at a depth of approximately 6 inches.

A topsoil sample was obtained from the check in each test at the time of fertilization in the spring. Leaf-blade samples were obtained from the check and treated areas in each test late in June or early in July. The leaf-blade samples were composed of 20 leaf blades, each obtained from the first leaf below the top visible dewlap.

Plot size was normally one-tenth of an acre, but was as large as three-tenths of an acre in some tests. Treatments were established as the check (no S) and the treated (with S) in eight to 10 replicates.

Leaf-blade samples were obtained from the check plots in five additional fertilizer or soil fertility tests and were analyzed for S contents. The S contents, together with S contents of leaf blades from check plots at 11 of the 38 tests with fertilizer S, were grouped according to age class of cane, i.e., plant, first stubble, and second stubble.

To study the relative uptake of fertilizer P and fertilizer S, three fertilizers tagged with radioisotopes were used. One fertilizer source (NPK fertilizer) was tagged with ^{32}P, another with ^{35}S (NKS fertilizer), and a third with ^{32}P and ^{35}S (NPKS fertilizer). Nutrients in the fertilizers, when present, were applied at rates to supply 160, 40, 80, and 24 pounds per acre of N, P_2O_5, K_2O, and S, respectively.

The radioactive fertilizers were applied in April of 1971 and 1972 to predetermined areas within four sites where tests were being conducted. The predetermined areas received nutrients only from radioactive fertilizers. The appropriate fertilizer was applied in each plot to 3 feet of row at a depth of 6 inches in the off-bar furrow. Each of the three fertilizers was applied in two replicates. Leaf-blade samples were obtained three times during the growing season at 3- to 5-week intervals, beginning late in June or early in July.

To ascertain the approximate degree of P and S movement in the soil, a laboratory study was made with Loring-Olivier silt loam topsoil to which radioactive fertilizers were applied. Four sets of Pyrex 60° funnels were prepared with filter paper. Each funnel received a constant weight of air-dry soil and fertilizer equivalent to the field application rate. Treatments in the four sets were: (1) fertilizer tagged with ^{32}P, mixed with the soil; (2) fertilizer tagged with ^{32}P, banded in a 1-inch diameter circle 1 inch below the soil surface and 1 inch from the filter paper; (3) fertilizer tagged with ^{35}S, mixed with the soil; and (4) fertilizer tagged with ^{35}S, banded in a 1-inch diameter circle 1 inch below the soil surface and 1 inch from the filter paper. Standards were prepared from the fertilizers by dissolving the materials with 0.1 normal hydrochloric acid. The standards and treated soils were leached twice with distilled water. Each leaching was equivalent to 2 inches of rainfall.

Soil and Plant Analysis Procedures

''Soil'' S and extractable S were determined by the method of Bardsley and Lancaster *(2)*. The method of Brupbacher, et al. *(4)* was used to determine P extractable from soils. Radioactivity in leaf blades was determined by methods suggested by the Nuclear Science Center, Louisiana State University. Total S in leaf blades was ascertained by the AOAC magnesium nitrate method *(1)*. Analysis for total P in leaf blades was made by digestion with concentrated nitric and perchloric acids and development of color by the chlorostannous-reduced molydophosphoric blue color method in hydrochloric acid system.

Statistical Analyses

Yield data were analyzed for degree of variance. Correlation coefficients and regression equations were obtained for the relationships among the values obtained for extractable S, leaf-blade S, and yield response to fertilizer S. Quadratic and cubic regressions were found to be nonsignificant.

Terminology

References to ''yield response'' or ''response'' were generally used in this report when responses were both positive and negative. When responses were positive, the term ''yield increase'' or ''increase'' was used.

Results and Discussion

Soil types on which field tests were conducted and other pertinent information are shown in Table 1. The soil types represent the general range in textural classes of soil on which most sugarcane production occurs

Table 1.—Experimental locations, soil types, varieties, and age classes of cane

Location					
No.	Plantation	Soil type	Year	Variety	Age class of cane[1]
1	Laurel Grove	Mhoon sicl	1966	CP52-68	1st St.
2	Little Texas	Mhoon sil	1966	CP52-68	2d St.
3	O'Neil	Baldwin sicl	1966	CP52-68	Pl.
4	Little Texas	Sharkey c	1967	NCo 310	2d St.
5	Laurel Grove	Mhoon sicl	1967	CP52-68	2d St.
6	O'Neil	Baldwin sicl	1967	CP52-68	1st St.
7	Evan Hall	Sharkey c	1968	CP55-30	1st St.
8	Laurel Grove	Mhoon sicl	1968	CP55-30	1st St.
9	Simonaud	Jeanerette sil	1968	NCo 310	1st St.
10	Evan Hall	Mhoon sicl	1969	L60-25	1st St.
11	Georgia	Mhoon sil	1969	CP52-68	Pl.
12	St. James	Mhoon sil	1969	CP55-30	1st St.
13	Belleview	Baldwin sicl	1969	CP52-68	1st St.
14	Kilgore	Jeanerette sil	1969	NCo 310	1st St.
15	Uncle Sam	Mhoon sicl	1970	L60-25	1st St.
16	St. James	Mhoon sicl	1970	L60-25	1st St.
17	Georgia	Mhoon sil	1970	CP52-68	1st St.
18	Belleview	Baldwin sicl	1970	CP52-68	1st St.
19	Perkins Road	Loring-Olivier sil	1970	L60-25	Pl.
20	St. James	Mhoon sicl	1971	L60-25	2d St.
21	Belleview	Baldwin sicl	1971	CP52-68	2d St.
22	Perkins Road	Loring-Olivier sil	1971	L60-25	1st St.
23	Westfield	Mhoon sicl	1972	L60-25	1st St.
24	Belleview	Baldwin sicl	1972	CP52-68	1st St.
25	Westfield	Mhoon sicl	1973	L62-96	2d St.
26	Belleview	Baldwin sicl	1973	CP52-68	2d St.
27	Belleview	Baldwin sicl	1974	CP52-68	3d St.
28	Oaklawn	Iberia c	1975	CP52-68	2d St.
29	Oaklawn	Iberia c	1975	L60-25	2d St.
30	Oaklawn	Iberia c	1975	L62-96	2d St.
31	Oaklawn	Iberia c	1975	L65-69	2d St.
32	Murphy	Iberia sicl	1976	NCo 310	1st St.
33	Oaklawn West	Baldwin sicl	1976	CP65-357	1st St.
34	Oaklawn West	Baldwin c	1976	CP61-37	2d St.
35	Greenwood	Sharkey c	1977	CP65-357	1st St.
36	Evan Hall	Sharkey c	1977	CP65-357	1st St.
37	East Camperdown	Baldwin sicl	1977	CP65-357	1st St.
38	East Camperdown	Baldwin sicl	1978	CP65-357	2d St.

[1] Pl. = plant cane, 1st St. = first stubble, 2d St. = second stubble.

in the vicinity of the Mississippi River, Bayou Lafourche, and Bayou Teche. Only three of the tests were with plant cane, since relatively small responses due to fertilizer elements normally occur in plant cane *(6, 10, 14, 15, 21, 22)*.

Yield Responses

Sugarcane yield responses as influenced by applied S and expressed as net and as standard tons per acre are shown in Table 2. Mean net and standard yield increases for the 38 locations were 1.11 and 1.71 tons per acre, respectively. The mean increases were highly significant. Generally,

Table 2.—Concentrations of soil S, extractable S, and leaf-blade S, and the yield responses to fertilizer S

Location no.	"Soil" S	Ext. S	Leaf-blade S content Check	Leaf-blade S content Treated	Yield response Net	Yield response Standard
	ppm	ppm	%	%	tons/A.	tons/A.
1	122	3.4	.071	.120	.57	1.81
2	148	4.8	.100	.154	.25	.81
3	179	8.3	.098	.113	- .02	1.11
4	376	7.8	.232	.248	.34	.36
5	124	3.6	.102	.187	1.67	3.45
6	174	9.8	.116	.135	.73	3.96
7	224	1.7	.087	.164	1.36	1.56
8	167	5.0	.118	.166	1.44	.91
9	173	4.9	.098	.143	2.40	2.32
10	141	5.3	.122	.150	.61	.74
11	97	6.7	.179	.211	.95	.49
12	141	3.3	.142	.151	1.08	.95
13	164	11.7	.128	.152	.06	1.84
14	155	6.7	.104	.133	.39	.26
15	141	21.0	.288	.294	- .07	- .56
16	199	13.3	.140	.176	1.34	1.50
17	94	7.3	.145	.201	- .81	.52
18	172	12.0	.161	.185	.70	1.89
19	90	18.8	.232	.234	-1.32	- .94
20	193	11.7	.176	.188	1.20	1.41
21	155	14.3	.148	.166	.76	1.14
22	86	17.2	.211	.224	- .09	.40
23	134	10.3	.113	.162	.69	.88
24	102	9.3	.100	.152	.89	1.06
25	170	23.3	.173	.182	.74	1.00
26	97	7.1	.096	.178	1.18	1.64
27	93	5.1	.082	.182	2.08	2.71
28	145	3.5	.102	.196	1.44	1.15
29	140	4.8	.109	.177	1.42	1.23
30	146	5.3	.104	.183	2.58	4.36
31	154	5.7	.104	.170	4.49	5.98
32	98	3.1	.130	.150	.28	.85
33	90	2.7	.130	.146	1.90	3.73
34	105	3.4	.141	.153	1.83	3.02
35	264	3.6	.109	.148	2.78	3.90
36	211	5.4	.141	.157	3.43	3.99
37	108	3.6	.089	.113	.71	.73
38	117	7.1	.099	.152	2.43	2.98

responses by plant cane and by stubble cane grown on the coarser textured or silt loam (sil) soils were small, and responses by stubble cane on finer textured or silty clay loam (sicl) and clay (c) soils were larger.

As related to textural classes of soils, responses to P and S applied together as normal superphosphate in 50 tests during 1958-66 *(14)* were similar to responses to S applied in this study. The responses were small on coarser textured soils. They were positive and generally larger on finer textured soils than increases from fertilizer S applied to finer textured soils in this study. In another series of tests with stubble cane on finer textured soils where P and S were applied separately and together, P as treble superphosphate and S as agricultural gypsum, increases from P and from S generally were about equal and increases from P and S when applied together were cumulative; that is, very little interaction effect on cane yield occurred *(10)*.

A summary of selected yield increases shown in Table 2 is provided in Table 3. The mean increases from medium-fine and fine-textured soils were 1.80 and 3.15 standard tons per acre, or 7 and 10 percent, respectively, and were highly significant. The difference in the mean increases, 1.35 standard tons per acre, approached significance.

The yields shown in Tables 2 and 3 indicate that in Louisiana fertilizer S in generally not needed by plant cane, nor by stubble cane on relatively coarse-textured soils and that fertilizer S is generally needed by stubble cane in most production areas when grown on relatively fine-textured soils.

Table 3.—Summary of yield increases due to fertilizer S applied to stubble cane grown on medium-fine and fine-textured soils[1]

Soil texture	No. of tests	Yield increase
		Standard tons/A
Medium fine (sicl)	19	1.80**[2]
Fine (c)	8	3.15**[3]

[1] Yield increases are means from Table 2.

[2] The test at Location 15 was not included since elemental S was used in the test and since leaf-S content from the check plots reflected S accumulation from local industrial activity.

[3] The test at Location 4 was not included due to very high leaf-blade S content from the check plots.

**Significant at the 1% level of probability.

Extractable S *vs.* Yield Response

The relationships of S extractable from topsoil and yield response to fertilizer S are shown in Figures 1 and 2. The correlations or r-values, $r = -.454$ for extractable S *vs.* net yield response, and $r = -.411$ for

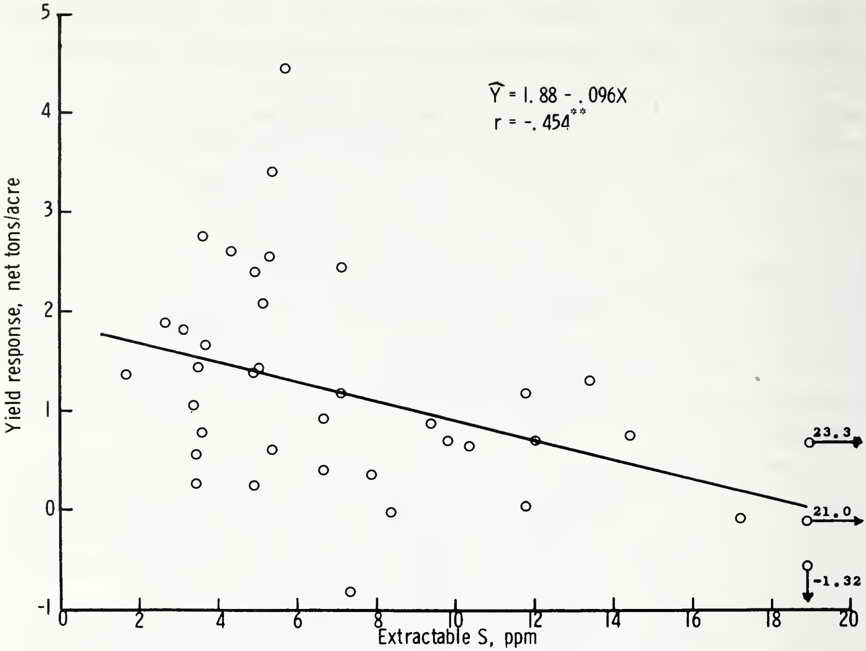

Figure 1. — Relationship of S extractable from topsoil and yield response to fertilizer S.

extractable S *vs.* standard yield response, are relatively small but statistically are highly significant.

Extractable S *vs.* Leaf-Blade S

The relationship of extractable S to leaf-blade S contents from cane grown in the check plots or plots that were fertilized only with N, NP, NK, or NPK is shown in Figure 3. The correlation, r = .699, was highly significant.

How extractable S related to increases in leaf-blade S that were influenced by fertilizer S is shown in Figure 4. The increases were calculated from check plot and treated values (Table 2). It may be noted that increases were generally larger on soils where extractable S values were relatively low, and that the correlation, r = —.491, was highly significant. Some of the small increases were associated with low amounts of rainfall during the period from the time S was applied, normally in April, and the time when leaf-blade samples were obtained, late in June or early in July *(10).*

Leaf-Blade S *vs.* Yield Response

Highly significant correlations were found between leaf-blade S contents from check plots and yield response to fertilizer S. The correlation

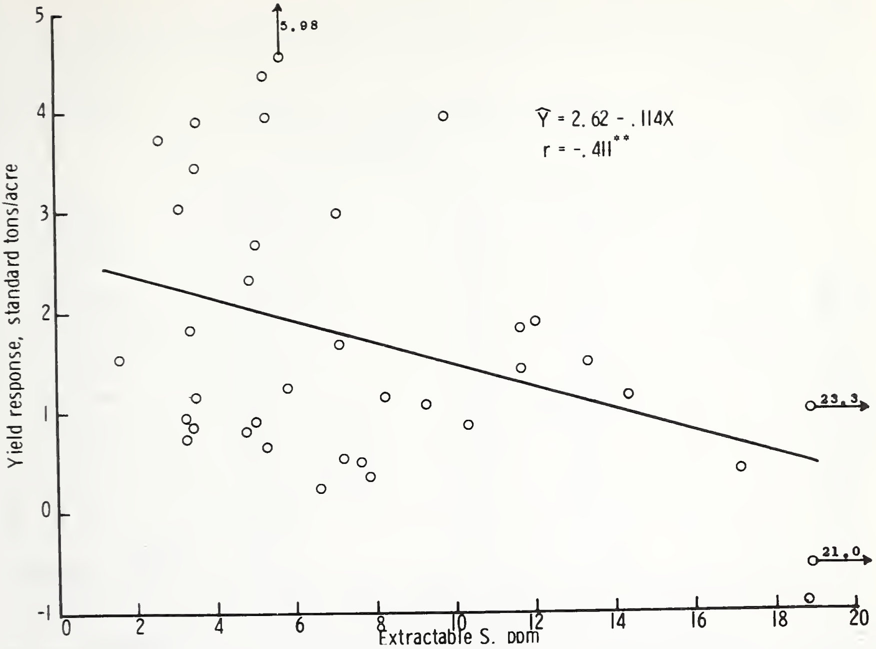

Figure 2. — Relationship of S extractable from topsoil and yield response to fertilizer S.

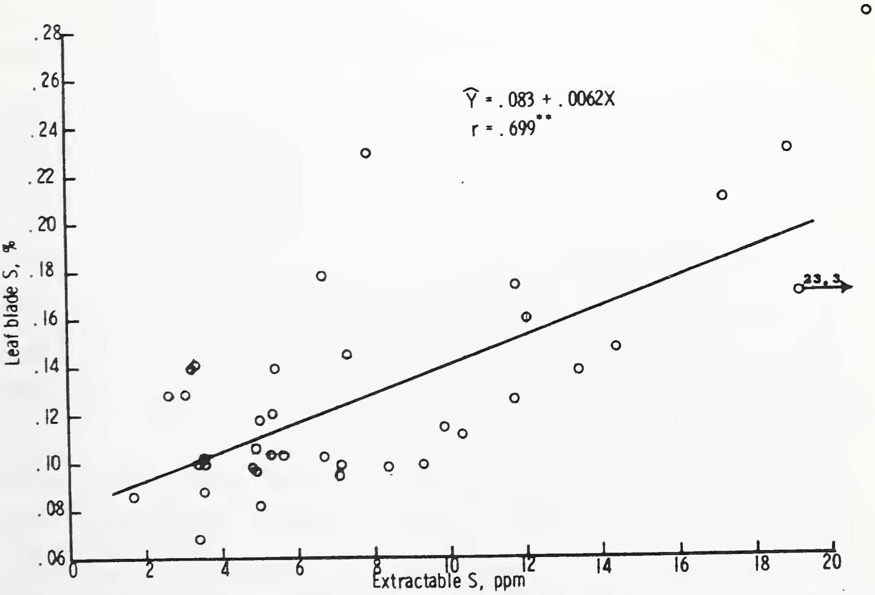

Figure 3. — Relationship of S extractable from topsoil to leaf-blade S contents from check plots.

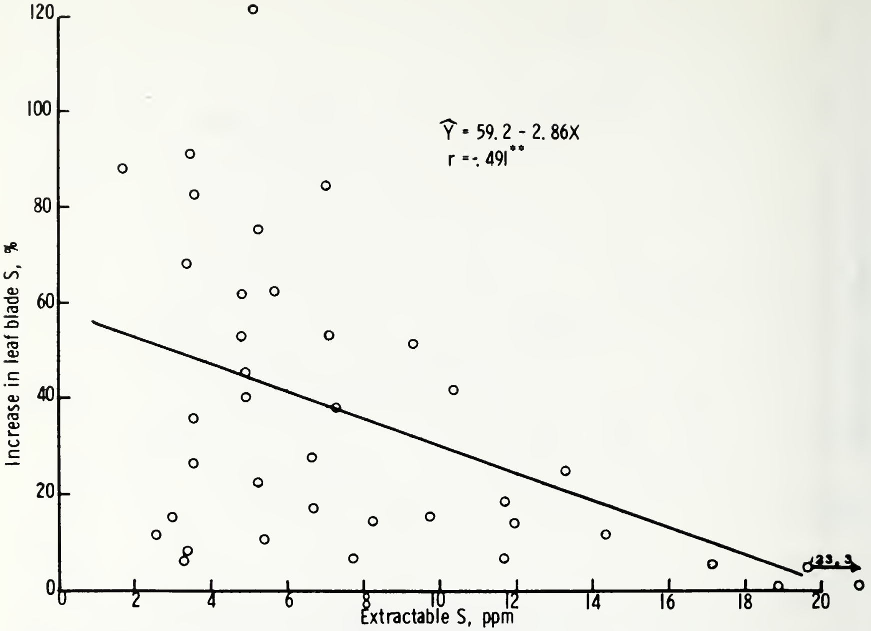

Figure 4. — Relationship of S extractable from topsoil to the increase in leaf-blade S as influenced by fertilizer S.

between leaf-blade S and net yield response was r = −.433, and the correlation between leaf-blade S and standard yield response was r = −.472. These were very similar to the correlations in Figures 1 and 2 between S extractable from topsoil and yield responses.

Age Class of Cane and Leaf-Blade S

Age classes of cane, i.e., plant cane, first stubble, and second stubble, as related to leaf-blade S contents are shown in Table 4. The locations reported include 11 that were among the 38 in the basic study (Table 1) and five additional locations at which tests were conducted with variables that did not include fertilizer S.

Generally, leaf-blade S contents were substantially lower from stubble cane than from plant cane, but differences between first and second stubble were small. The means of leaf-blade S from plant, first stubble, and second stubble cane at the eight locations where samples were obtained during each of the 3 crop years were .147 percent, .111 percent, and .106 percent, respectively.

Table 4.—S contents of leaf blades[1] in different age classes of cane

Location					Leaf-blade S		
No.	Plantation	Soil type	Years	Variety	Pl.	1st St.	2d St.
					---------- % ----------		
1	O'Neil	Baldwin sicl	1966-67	CP52-68	.098	.116	
2	Georgia	Mhoon sil	1969-70	CP52-68	.179	.145	
3	Georgia	Mhoon sil	1969-70	CP52-68	.159	.135	
4	Katy	Baldwin sicl	1969-71	CP52-68	.165	.093	.107
5	Simonaud	Jeanerette sil	1969-71	CP52-68	.139	.097	.122
6	Perkins Road	Loring-Olivier sil	1970-71	L60-25	.232	.211	
7	Belleview	Baldwin sicl	1970-71	CP52-68		.161	.148
8	Belleview	Baldwin sicl	1972-73	CP52-68		.100	.096
9	Oaklawn	Baldwin sil-Iberia c	1973-75	CP52-68	.146	.119	.102
10	Oaklawn	Baldwin sil-Iberia c	1973-75	L60-25	.146	.124	.109
11	Oaklawn	Baldwin sil-Iberia c	1973-75	L62-96	.150	.131	.104
12	Oaklawn	Baldwin sil-Iberia c	1973-75	L65-69	.140	.113	.104
13	O'Neil	Baldwin sicl	1974-75	CP52-68	.162	.122	
14	Belleview	Baldwin sicl	1975-77	CP52-68	.169	.115	.094
15	East Camperdown	Baldwin sicl	1976-78	CP65-357	.121	.086	.109
16	East Camperdown	Baldwin sicl	1977-78	CP65-357		.089	.099

[1] Leaf-blade samples were obtained from check plots or plots that received no fertilizer S or other treatment containing S.

Fertilizer P and Fertilizer S in Leaf Blades

Fertilizer P and fertilizer S contents of leaf blades as related to fertilizer treatment with radioactive P and S are shown in Tables 5 and 6. For each date of sampling, portions of the elements that were obtained from fertilizers were averaged and are shown graphically in Figures 5 through 8. For example, in Table 5, leaf blades obtained on July 1 from cane grown on Baldwin silty clay loam contained 24 and 22 percent of their total P from the P and PS fertilizer treatments, respectively. The average, 23 percent, was plotted in Figure 5. The P and S contents of leaf blades probably represent quite well the total P and S contents of the entire cane plants, since previous work *(15)* has shown highly significant positive correlations between leaf-blade P and above-ground P contents and between leaf-blade S and above-ground S contents.

It may be noted in Tables 5 and 6 and in Figures 5 through 8 that the amounts of fertilizer S in leaf blades were generally much higher than the amounts of fertilizer P. The exceptions were in July and August 1972 at Belleview Plantation where the amount of rainfall was exceptionally low from mid-June through August (Figure 7). Some of the greater uptake of S was apparently due to the difference in rates of P and S applied. The rate of

Table 5. — Fertilizer P and fertilizer S contents of leaf blades as influenced by P, S, and PS fertilizer treatments applied to two soil types in 1971

		P in leaf blades			S in leaf blades		
Date sampled	Fert. treatment	Total	Fert.	Portion from fert.	Total	Fert.	Portion from fert.
		%					
		Baldwin sicl					
July 1	P	.157	.038	24	.117		
	S	.131			.144	.042	29
	PS	.150	.033	22	.140	.032	23
July 28	P	.130	.027	21	.085		
	S	.125			.120	.032	27
	PS	.130	.022	17	.102	.029	28
Aug. 24	P	.122	.017	14	.076		
	S	.124			.099	.031	31
	PS	.117	.015	13	.096	.027	28
		Mhoon sicl					
July 1	P	.196	.033	17	.137		
	S	.172			.186	.065	35
	PS	.168	.022	13	.170	.061	36
July 28	P	.167	.022	13	.120		
	S	.156			.134	.036	27
	PS	.154	.014	9	.128	.041	32
Aug. 24	P	.148	.015	10	.115		
	S	.135			.124	.026	21
	PS	.141	.009	6	.120	.028	23

P, expressed on an elemental basis, was 17.3 pounds per acre, and the rate of S was 24 pounds per acre. The portions of P in leaf blades from fertilizers applied to cane grown on Baldwin soils were higher than those from fertilizers applied to cane grown on Mhoon soils and were generally related negatively to extractable soil P.

The extractable P and S values shown in Figures 5 through 8 are not directly comparable. Differences exist in the extractant employed and in the amounts and nature of the elements in the soil. Although the total amount of S in soils cropped to sugarcane in Louisiana generally is considerably lower than the total amount of P *(6, 12, 13, 15)*, a higher portion of the total S is generally contained in organic matter *(2, 5, 6, 12)* from which it cannot be readily extracted by standard methods.

Table 6.—Fertilizer P and fertilizer S contents of leaf blades as influenced by P, S, and PS fertilizer treatments applied to two soil types in 1972

Date sampled	Fert. treatment	P in leaf blades			S in leaf blades		
		Total	Fert.	Portion from fert.	Total	Fert.	Portion from fert.
		%					
		Baldwin sicl					
June 20	P	.158	.026	16	.090		
	S	.171			.112	.032	29
	PS	.183	.033	18	.104	.028	27
July 19	P	.135	.022	16	.130		
	S	.139			.132	.016	12
	PS	.163	.024	15	.113	.017	15
Aug. 22	P	.143	.019	13	.120		
	S	.142			.139	.018	13
	PS	.156	.019	12	.153	.015	10
		Mhoon sicl					
July 6	P	.142	.014	10	.091		
	S	.178			.119	.043	36
	PS	.160	.018	11	.116	.036	31
Aug. 7	P	.158	.014	9	.143		
	S	.156			.142	.041	29
	PS	.159	.021	13	.117	.028	24
Aug. 22	P	.159	.011	7	.172		
	S	.147			.150	.035	23
	PS	.163	.015	9	.145	.032	22

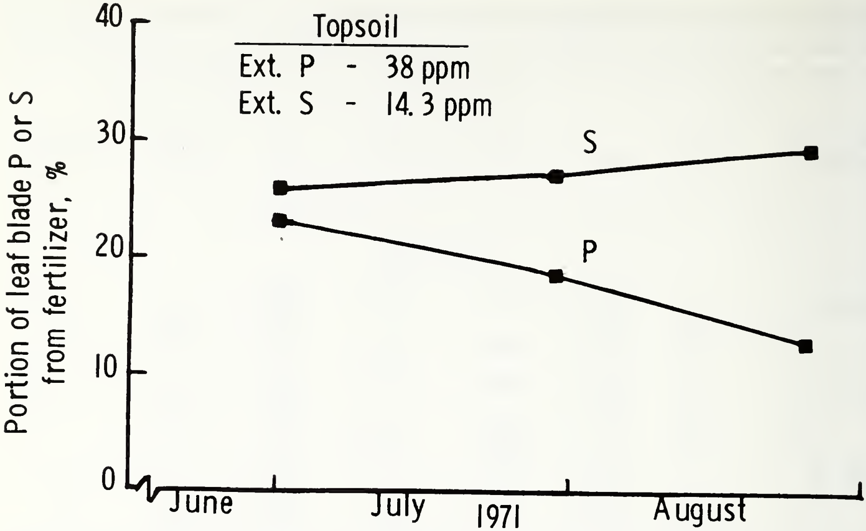

Figure 5. — Fertilizer P and S contents of leaf blades from CP52-68 stubble cane on Baldwin sicl at Belleview Plantation.

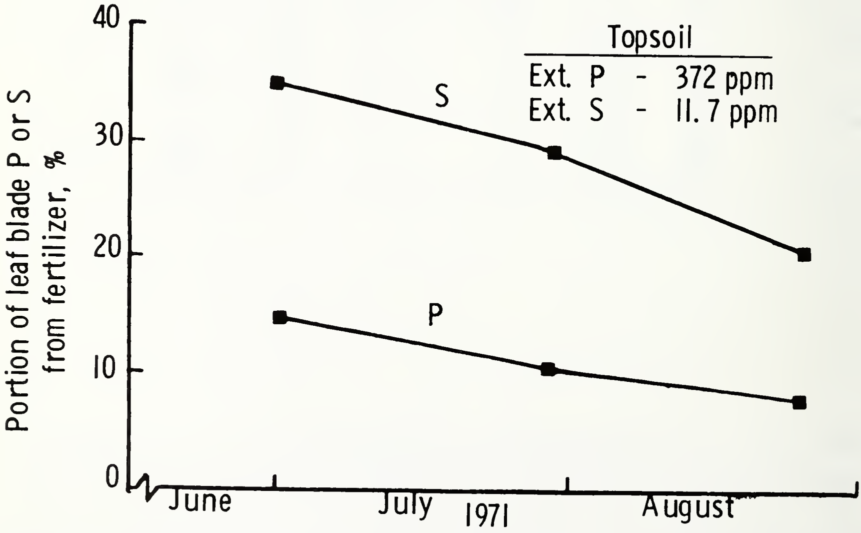

Figure 6. — Fertilizer P and S contents of leaf blades from L60-25 stubble cane on Mhoon sicl at St. James Plantation.

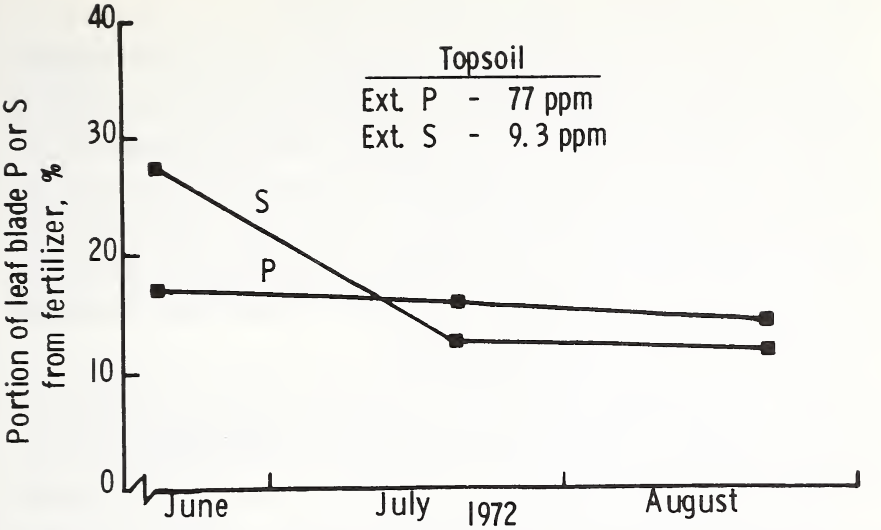

Figure 7. — Fertilizer P and S contents of leaf blades from CP52-68 stubble cane on Baldwin sicl at Belleview Plantation.

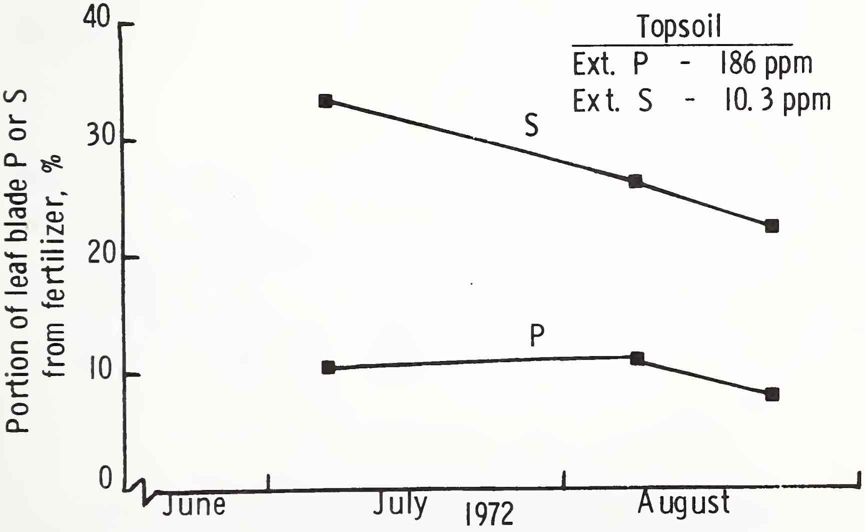

Figure 8. — Fertilizer P and S contents of leaf blades from L60-25 stubble cane on Mhoon sicl at Westfield Plantation.

Movement of Fertilizer P and Fertilizer S in Soil

The movement of S from the banded treatment at the first leaching was approximately 10 percent, and the movement from the mixed treatment was about twice that amount (Table 7). These determinations were made by comparing disintegrations per minute (dpm) from the treatments with the standard. Movement of S from the banded treatment was higher than from the mixed treatment at the second leaching due to more S remaining in and near the band following the first leaching. The total amounts of S transported from the zones of placement resulting from both leachings, or due to water equal to 4 inches of rainfall, were about 36 percent from the banded and 39 percent from the mixed treatments.

The total amounts of P transported from zones of placement were each shown by 15 counts per minute (cpm) resulting from the two leachings, or each represented movement of about one-half percent (Table 8).

Discussion

Correlations shown in Figures 1 through 4, which indicated the relationships of S extracted from soils to yield responses and to leaf-blade S, were generally low. However, the fact that each relationship was highly significant indicates that substantial justification exists for use of extractable

Table 7.—Movement of ^{35}S from fertilizer applied to Loring-Olivier silt loam

Treatment	Radioactivity		
	First leaching	Second leaching	Total
	dpm		
Standard	6,785	45	6,830
Banded	672	1,775	2,447
Mixed	1,345	1,343	2,688

Table 8.—Movement of ^{32}P from fertilizer applied to Loring-Olivier silt loam

Treatment	Radioactivity		
	First leaching	Second leaching	Total
	cpm		
Standard	2,949	4	2,953
Banded	6	9	15
Mixed	5	10	15

soil S as a factor when recommending fertilizer S for sugarcane. Likewise, information in Figures 3 and 4 provides justification for use of leaf-blade S content as a factor when recommending fertilizer S for sugarcane.

From the information presented in Tables 1 through 8, Figures 1 through 8, and related discussion, it appears that the relatively large amount of S uptake from fertilizers is associated with: (1) substantial need for fertilizer S by sugarcane on some soils, (2) luxury consumption on some soils from which very little yield response is expected, (3) small amounts of available S in soils, and (4) generally wide distribution of fertilizer S in the root zone due to its solubility and mobility.

Proposal

Based on information obtained in this study, standard values shown in Table 9 are proposed for S extractable from soils and for leaf-blade S contents as they relate to production of sugarcane in Louisiana.

Table 9.—Standard extractable soil S and leaf-blade S contents for sugarcane in Louisiana

Status of soil/sugarcane	Extractable S[1]	Leaf-blade S[2]	
		Plant cane	Stubble cane
	ppm	%	
Very low	<3	<.13	<.10
Low	3 - 6	.13 - .16	.10 - .13
Medium	6 - 10	.16 - .20	.13 - .17
High	10 - 15	.20 - .25	.17 - .22
Very high	>15	>.25	>.22

[1] Extractable S values are suggested for use primarily when interpreting results from medium-fine to fine-textured soils. Generally, they should not be used as the only basis for sugarcane grown on coarse- to medium-textured soils.

[2] Leaf-blade samples should be obtained late in June or early in July. Results from analyses may be considered for the crop that follows the crop sampled, and for other sugarcane on similar soils in the vicinity.

Summary and Conclusions

An investigation was made to determine the relationships of soil, fertilizer, and leaf-blade S to sugarcane yields. Field tests were conducted, primarily with stubble cane, in which 24 pounds of S per acre per year were applied in the sulphate form. The major soil types where sugarcane is produced were included in the study.

From the 38 tests conducted, the average annual sugarcane yield increase due to fertilizer S was 1.71 standard tons per acre. The average increase from 27 of the tests which were on medium-fine to fine-textured soils was 2.20 standard tons per acre.

Highly significant negative correlations were obtained between S extractable from topsoil and net yield response to fertilizer S, and between extractable S and standard yield response to fertilizer S. A highly significant positive correlation was obtained between extractable S and leaf-blade S contents from check plots, and a highly significant negative correlation occurred between extractable S values and increases in leaf-blade S as influenced by fertilizer S.

Generally, where no fertilizer S was applied, leaf-blade S contents from stubble cane were substantially lower than from plant cane.

It was concluded that the relatively high amount of fertilizer S absorbed by sugarcane on finer textured soils was due to substantial need for fertilizer S by the sugarcane and to the moderately high amount of movement and solubility of fertilizer S in the root zone.

Advantages and disadvantages exist for use of various means or bases in recommending fertilizer S for sugarcane in Louisiana:

1. *Visual observation.* Since the symptoms for S deficiency in sugarcane are similar to those for N deficiency, visual observation does not appear to be valid as a basis.

2. *General recommendation.* A recommendation that no fertilizer S should be applied to plant cane and stubble cane on coarse- to medium-textured soils, and that fertilizer S should be applied to stubble cane on medium-fine to fine-textured soils, has its basis in Tables 2 and 3 and related discussion. Where filter-press mud has been applied, lesser amounts or no fertilizer S may be needed. The effect of filter-press mud may be vertified by soil analysis, but leaf analysis is considered better for this purpose.

3. *Extractable S.* For routine or standard work, determination of S extractable from soil is generally less expensive than leaf analysis. The amount of extractable S in finer textured topsoil may serve as the only basis for recommending fertilizer S. This is due to limited uptake of S from subsoil as influenced by generally low oxygen content and poor root development. For coarser textured soils, one or two subsoil samples may be needed in addition to the topsoil sample, at each topsoil sampling site, but results from analysis of a leaf sample from each site should provide the information desired. Although not a part of this study, information is available concerning S extractable from subsoils in the sugarcane producing area of Louisiana *(14, 23)*.

4. *Leaf-blade S.* Provided normal rainfall occurred prior to sampling, results from leaf-blade analysis should indicate the need for use of fertilizer S on all soil types. Where soil test values from coarser and from finer textured soils are approximately equal, S uptake from the coarser soil is normally higher due to greater absorption of S from subsoil *(20)*.

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Influence of Soil Reaction and Zinc Applications on Yields and Zinc Contents of Rice Plants

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Influence of Soil Reaction and Zinc Applications on Yields and Zinc Contents of Rice Plants

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Introduction

Zinc deficiency was first observed in Louisiana in flooded rice fields by Peterson *et al*. (1966). The disorder was subsequently confirmed by Engler (1969). Zinc deficiency is now recognized as an important nutritional disorder that affects rice grown on approximately 15 percent of the soils in the Prairie area of southwestern Louisiana (Sedberry *et al.,* 1978). Zinc deficiency in rice has been noted on soils with a neutral to alkaline pH. Rice plants growing on alkaline soils have exhibited a condition commonly referred to as "bronzing." The "bronzing" of the leaves is thought to be due to inadequate amounts of Zn in the soil and in the leaves of rice plants.

The objective of this investigation was to determine the influence of different soil pH levels and application of Zn on the yield of rice and the chemical composition of rice plants grown on Crowley silt loam (Typic Albaqualf).

Review of Literature

Ryker and Sturgis (1939) reported that there were certain soils in southwestern Louisiana with relatively high pH values. Rice plants grown on these soils usually showed severe root rot and produced low grain yields. Application of 600 and 1,200 pounds of S per acre to alkaline soils significantly increased yields. Soils in these alkaline spots undoubtedly contained low levels of Zn and possibly low levels of other micronutrient elements as well.

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The physiological disorder of rice referred to as "bronzing" has been described and attributed to inadequate soil-Zn levels by F. R. Cox and J. I. Wear (1977).

Zinc-deficiency symptoms of rice are sometimes difficult to diagnose. The midribs of young leaves first become chlorotic, brown spots or streaks later develop in lower leaves, and plant growth is stunted. Zinc-deficient young seedlings wither and die from the tops downward. After true leaves have developed, Zn-deficiency symptoms generally appear as light-yellow to rusty-brown lesions on stems and leaves. In the tillering stage, lesions on Zn-deficient plants resemble rust infections. Under flooded conditions, Zn-deficient plants appear very listless and the bottom leaves float on the water surface. All leaves of such plants have a rather pale yellow-green color. These visual symptoms have been described by Sam P. Firmin, former county agent, Acadia Parish, Louisiana (personal communication).

Yoshida and Tanaka (1969) confirmed that "Khaira" disease of rice in north-central India and the "Hadda" disorder was referred to as "bronzing" because of the brown discoloration of plant leaves.

According to Yoshida and Tanaka (1969), and Sedberry *et al.* (1971) (1978), the critical level of Zn in rice tissue is approximately 15 ppm. However, the ashing technique used is very important in establishing critical levels of Zn and other micronutrient elements in rice-plant tissue. Consistently lower values for Zn are usually obtained when the tissue is dry ashed in a muffle furnace as compared with values from wet-acid digestion. Dry ashing of plant material invariably leaves a Si residue which adsorbs traces of micronutrients. This adsorption particularly affects rice tissue which contains relatively high amounts of Si. Zinc losses due to adsorption on Si may be as high as 25 percent or more unless Si is first removed by treatment with HF.

Said (1979) found that quantities of Zn extracted from 25 samples of air-dried soil with four extracting solutions were larger than amounts extracted from soils that had been flooded with distilled water for 6 weeks. He also reported that flooding increased the pH of all soils.

There are several reasons for the decreased availability of Zn under reduced conditions found in flooded soils in addition to high soil pH or calcareous material. Yoshida and Tanaka (1969) and Ponnamperuma (1972) reported that ZnS may be formed as $SO_4=$ is reduced to H_2S in flooded soils. The solubility of ZnS is extremely low. Zinc may also be absorbed by Ca and Mg carbonates. Zinc is more strongly absorbed by magnesite, $MgCO_3$; it is absorbed less by dolomite, $CaMg(CO_3)$; and is absorbed least by calcite, $CaCO_3$. Magnesite and dolomite appear to adsorb Zn into the crystal surfaces at sites in the lattice normally occupied by Mg atoms (Tisdale and Nelson, 1966). Precipitation of Zn as carbonates, hydroxides, and phosphates can also reduce the availability of Zn.

Experimental Details

This investigation began in 1967 and continued through 1974 to study the influence of three pH levels resulting from different limestone application rates and two zinc application rates on rice yields and Zn composition of rice plants grown on Crowley silt loam (Typic Albaqualf).

Five years before start of the investigation, the soil had been "water-leveled" to facilitate flooding and draining. Certain physical and chemical properties of Crowley silt loam soil after "water-leveling" are shown in Table 1.

The experimental design was a split-plot. Limestone amendments were applied on main plots and Zn treatments were applied on subplots. Each treatment combination was replicated three times. In 1975, the experiment was modified to include S applications as a variable with limestone and Zn treatments. Yield data were not collected in 1967. In an effort to control an infestation of red rice, soybeans were grown on the experimental plots in 1971 and 1972.

Dolomitic limestone was applied in 1967 and none was applied in subsequent years. Sulphur was broadcast on the surface of the soil on certain plots at the rate of 500 pounds per acre in 1975. Similar amounts of S were applied in 1977. Zinc-chelate (14.2 percent Zn) was applied annually at a rate equivalent to 1.7 pounds of Zn per acre. Zinc material in a water solution was applied to the soil surface with a gravity flow applicator.

An annual application of 120 pounds of N, 22 pounds of P, and 42 pounds of K per acre was applied uniformly to each plot with a drill before plots were planted. Urea (46 percent N), concentrated phosphate (20.2 percent P), and muriate of potash (50 percent K) were the sources of N, P, and K, respectively.

Saturn rice was grown from 1967 to 1970; Vista rice was grown from 1973 through 1978. Rice was planted at a seeding rate of 90 pounds per acre. Seed in each plot were drilled in 12 rows spaced 7 inches apart. Each plot was 7-feet by 50-feet.

Soil samples were collected annually from each of the plots before application of fertilizer. Soil samples were placed in 18-ounce plastic bags

Table 1.—Physical and chemical properties of Crowley silt loam

Physicial properties[1]			Chemical properties								
Sand	Silt	Clay	P	K	Ca	Mg	Mn	Cu	Fe	pH	O.M.
	%					ppm					%
9.1	70.6	20.3	13	85	960	480	45	2.3	37.7	6.8	1.1

[1] Particle size distribution of sand, silt, and clay was determined with a hydrometer and sieve.

for transport to the laboratory. After air-drying, the pH, organic matter content, and macronutrient element status of soil samples were determined by the methods currently used in the soil testing laboratory. Zinc was extracted from the soil samples with 0.005 *M* DTPA and 0.01 *M* $CaCl_2$; 0.1 *M* TEA was used to buffer samples (pH 7.3). A soil-to-solution ratio of 1:2 and an extracting period of 2 hours were used to determine extractable-Zn levels.

Leaf samples were collected from rice plants growing on each plot. The leaf-tissue samples consisted of 50 mature leaves taken when the rice panicle was approximately 2 mm long. The leaves were rinsed in distilled water and placed in cotton bags for transport to the laboratory. The leaves were dried in a forced-draft oven at 70°C for 24 hours, ground in a stainless-steel Wiley mill to pass a 20-mesh sieve, and stored in 4-ounce glass containers.

The leaves were ashed in a 1:3 mixture of concentrated $HClO_4$ and HNO_3 acids. Zinc concentration in the filtrate was determined by an atomic absorption spectrophotometer.

Yield, leaf tissue, and soil chemical analyses data were evaluated in a split-plot experiment with analysis of variance in a randomized design and correlation regression analyses.

Results and Discussion

Effects of applications of limestone and Zn on the yield of rice grown on Crowley silt loam during a 5-year period are shown in Table 2. The data show that average yields from plots that did not receive Zn were reduced by 964 pounds per acre when 2 tons of limestone per acre were applied.

Yields were further reduced by 1,388 pounds per acre when 4 tons of limestone per acre were applied. Applying Zn to plots that did not receive limestone significantly increased yields in 1969 and 1970. Application of Zn to soil that received 2 and 4 tons of limestone per acre significantly increased yields over the 5-year period. The effect of Zn was more pronounced when it was applied to soil receiving the higher rate of limestone. Application of Zn to plots that received 4 tons of limestone per acre significantly increased yields in each of the 5 years. When Zn was not applied, each of the 4 tons of limestone caused a 588-pound-per-acre reduction in yield. Applying 4 tons of limestone per acre to soil that received Zn reduced rice yields by 176 pounds per acre per ton of limestone.

The pH of Crowley silt loam in experimental plots varied considerably within each year and from year-to-year. The variation in soil pH was thought to be due to soil heterogeneity and "water-leveling." The movement and mixing of soil with mechanical equipment during "water-leveling" was not uniform. Deep cuts exposed subsoil in certain areas that contained calcareous material with relatively high and variable pH values.

Table 2.—Effects of limestone and zinc applied to Crowley silt loam on rice yields (1968-74)

Limestone applied (Tons/Acre)[1]	Year[2]	Soil pH (Range)	Rice yields (Lbs./Acre)[3] Zinc treatments No Zn	Zn[4]	Difference
	1968	6.5-7.1	5,095	5,443	348
	1969	6.7-7.3	2,713	4,174	1,461
0	1970	6.5-7.6	2,788	4,478	1,690
	1973	6.4-7.5	4,464	4,871	407
	1974	6.6-7.4	5,298	6,440	1,142
	5-year average:		4,072	5,081	1,009
	1968	7.2-7.8	2,590	4,053	1,463
	1969	7.4-7.9	1,968	3,184	1,216
2	1970	7.1-7.9	2,068	4,240	2,172
	1973	7.0-7.9	4,212	4,386	174
	1974	7.0-7.7	4,701	5,510	809
	5-year average:		3,108	4,275	1,167
	1968	7.5-7.9	1,240	3,940	2,700
	1969	7.6-8.0	1,035	3,344	2,309
4	1970	7.5-7.9	800	4,190	3,390
	1973	7.4-7.9	3,033	4,479	1,446
	1974	7.1-7.9	2,490	5,926	3,436
	5-year average:		1,720	4,376	2,656

	Zinc comparisons $LSD_{.05}$	CV (%)
1968	1,305	21.9
1969	1,044	23.9
1970	1,591	32.2
1973	493	7.1
1974	1,745	17.2
Combined	517	21.3

---

[1] Dolomitic limestone was applied in 1967.

[2] Rice was rotated with soybeans in 1971 and 1972.

[3] Average of four replications in 1968-73. Average of three replications in 1974. Grain yields adjusted to 12% moisture.

[4] Zinc was applied annually at a rate equivalent to 1.7 pounds of zinc per acre as zinc chelate (14.2% zinc).

The effects of applications of limestone and Zn on soil-Zn and leaf-Zn levels are shown in Table 3. Annual application of 1.7 pounds of Zn per acre to the soil significantly increased the average concentration of Zn extracted with DTPA-TEA, pH 7.3, over the 5-year period. Research conducted in conjunction with this investigation showed that 0.7 ppm of Zn extracted from the soil with DTPA-TEA was a marginal Zn level for the economical production of rice (Sedberry *et al.*, 1978). Zinc treatment did not significantly increase the concentration of leaf-Zn in all years. How-

Table 3.— Effects of limestone and zinc applied to Crowley silt loam on soil-zinc and leaf-zinc content (1968-74)

			Zinc content[1]			
			No zinc applied		Zinc applied	
Limestone applied (Tons/Acre)	Year	Soil pH (Range)	Soil[2]	Leaf[3]	Soil[2]	Leaf[3]
0	1968	6.5-7.1	0.5	9	1.7	12
	1969	6.7-7.3	0.5	16	0.6	24
	1970	6.5-7.6	1.2	21	1.8	26
	1973	6.4-7.5	2.1	15	2.0	21
	1974	6.6-7.4	1.6	13	2.6	23
	5-year average:		1.2	15	1.7	21
2	1968	7.2-7.8	1.3	8	1.7	10
	1969	7.4-7.9	0.5	15	0.5	22
	1970	7.1-7.9	1.3	20	1.6	30
	1973	7.0-7.9	1.6	14	2.0	21
	1974	7.0-7.7	1.8	14	2.5	24
	5-year average:		1.3	14	1.7	21
4	1968	7.5-7.9	1.2	8	1.8	10
	1969	7.6-8.0	0.5	18	0.5	29
	1970	7.5-7.9	1.2	19	1.8	25
	1973	7.4-7.9	1.6	14	2.3	21
	1974	7.1-7.9	1.6	12	2.7	22
	5-year average:		1.2	14	1.8	21

	Zinc comparisons	
	$LSD_{.05}$ (ppm)	CV (%)
Soil zinc (combined)	.03	11.6
Leaf zinc (combined)	8.00	31.4

---

[1] Average of four replications.

[2] Zinc was extracted from soil with the DTPA-TEA method. Zinc content of filtrate was determined on an atomic absorption spectrophotometer.

[3] Leaf tissue was digested in a 3:1 mixture of HNO_3 and $HClO_4$.

ever, consistently higher Zn concentrations in rice-leaf tissue were found following Zn applications. Both annual Zn concentrations and average Zn concentration over the 5-year period in tissue from plots receiving Zn were consistently higher than concentrations found in tissue taken from plots that did not receive Zn. Rice plant leaves that contain less than 15 ppm of Zn are considered to contain lower-than-recommended concentrations of Zn (Sedberry *et al.,* 1971).

Deficiency symptoms attributed to low tissue-Zn levels were observed on rice plants growing on plots that did not receive an application of Zn. In early stages of growth, the symptoms appeared as a sudden blighting of older leaves of the seedling. The lesions were surrounded by chlorotic areas which became white. Lesions and chlorotic areas extended from the sheath up the midrib of the older true leaf, parallel to the leaf vein. As the disorder developed, the base of the leaf blade and midvein became bleached with brown flecks, spots, and irregular linear blotches. Affected leaves rapidly blighted and the seedlings appeared to die. However, removing the blighted outer leaves showed that the youngest leaf remained green. Cool, overcast weather contributed to the symptoms, and extended periods of adverse weather, together with a high infestation of rice water weevils, increased the intensity of the observed symptoms of Zn deficiency.

Zinc-deficiency symptoms often are not expressed until fields are permanently flooded. Lower leaves of affected plants first become limp and float on the surface of the flood water. These leaves rapidly turn yellow-orange and develop small brown flecks. In the more severely affected areas of fields or in deep water, seedlings begins to disappear below the surface of the flood water, rice stand thins, and areas of open water appear. Zinc-deficient plants that do not die are often stunted and have brown flecks on the leaf blades. These flecks expand into irregular, linear, purple-brown blotches on older leaves. If the affected plants have responded to an application of N fertilizer before plants show ''bronzing'' symptoms, a distinctive chlorotic area which rapidly becomes white is often observed in the midleaf area and around the brown blotches. The leaf blade or tip of the blade may become bronze due to the formation and coalescence of many small purple-brown flecks. From a distance, the plants in a field appear to take on a bronze to gold color. Plants in the affected field often exhibit typical N-deficiency symptoms as well as symptoms typical of ''bronzing.'' Zinc-deficiency appears to interfere with the normal utilization of N.

Plants can exhibit Zn-deficiency symptoms at any stage of growth. If plants become deficient at heading, the leaves and glumes will show the typical chlorosis, brown flecking, and spotting. Severe Zn-deficiency during heading will affect florets. A condition similar to straighthead may occur where panicles of affected plants remain upright as pollination fails to take place or as kernel development is aborted.

The effects of limestone, S, and Zn applied to Crowley silt loam on rice yields during a 4-year period are shown in Table 4. Soil pH varied considerably during each year and from year-to-year at all levels of applied limestone and S. Variations in soil pH on plots that did not receive limestone and S indicated that differences in pH were not due to the nonuniform distribution of these two amendments.

In the first year, increasing limestone application rates resulted in a corresponding reduction in rice yields (Table 4). Application of 4 tons of limestone per acre significantly reduced yields by approximately 2,000 pounds per acre. The yield depression resulting from the limestone treatments was counteracted by the application of either S or Zn. In general, rice yields increased on nonlimed soil when S and/or Zn were applied. In 1976, applying limestone and S did not influence yields significantly. No significant interaction was found among the different treatments. Applying Zn

Table 4.—Effects of limestone, sulphur, and zinc applied to Crowley silt loam on rice yields (1975-78)

				Rice yields (Lbs./Acre)[2]		
				Zn treatments		
Limestone applied (Tons/Acre)	Sulphur treatment[1]	Year	Soil pH (Range)	No Zn	Zn[3]	Difference
0	No S	1975	6.4-7.1	4,407	5,343	936
		1976	6.4-7.3	3,728	4,672	944
		1977	6.4-7.1	3,823	4,373	550
		1978	6.6-7.4	2,960	3,840	880
		4-year average:		3,730	4,557	827
0	S	1975	6.2-7.4	4,844	5,472	628
		1976	5.4-6.9	4,204	4,751	547
		1977	5.7-6.7	4,326	4,492	166
		1978	5.8-6.8	3,990	4,220	230
		4-year average:		4,341	4,734	393
2	No S	1975	6.8-7.6	3,763	4,620	857
		1976	6.7-7.7	3,411	4,285	874
		1977	6.3-7.7	3,022	4,002	980
		1978	7.1-8.0	2,490	3,190	700
		4-year average:		3,172	4,024	852
2	S	1975	6.7-7.8	4,589	4,805	216
		1976	5.9-7.3	3,720	4,355	635
		1977	5.8-7.5	4,053	4,417	364
		1978	5.9-7.5	3,200	3,830	630
		4-year average:		3,891	4,352	461
4	No S	1975	6.9-7.7	2,382	5,070	2,688
		1976	6.7-7.8	2,699	4,638	1,939
		1977	6.7-7.8	1,925	4,234	2,309
		1978	7.2-8.1	2,420	3,530	1,110
		4-year average:		2,357	4,368	2,011
4	S	1975	6.7-7.5	3,674	4,903	1,229
		1976	6.1-7.5	2,982	4,211	1,229
		1977	6.1-7.4	3,334	4,096	762
		1978	5.9-7.9	2,890	3,720	830
		4-year average:		3,220	4,233	1,013

Treatment comparisons

		$LSD_{.05}$
1975	Limestone	1,195
	Zinc	1,063
	Limestone × zinc	1,841
	Sulphur	287
	Limestone × sulphur	497
	Zinc × sulphur	406
	Limestone × zinc × sulphur	703
1976	Zinc	1,168
1977	Zinc	657
	Sulphur	524
1978	Zinc	492
Combined	Zinc	1,029 CV = 15.8% 1,029

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[1] Sulphur was applied at a rate of 500 pounds per acre in 1975 and 1977.

[2] Average of three replications. Grain yields adjusted to 12% moisture.

[3] Zinc chelate (14.2% Zn) was applied annually at a rate equivalent to 1.7 pounds of zinc per acre.

alone, and applying Zn with limestone and S in the second year, increased yields significantly. In 1977, the residual affects of previous limestone applications did not significantly influence yields. However, lower yields were obtained on plots that received 2 to 4 tons of limestone per acre when S and Zn were not applied. Application of Zn and S, with or without limestone, significantly increased yields.

In 1978, the residual effects of limestone applications did not significantly influence yields; however, yields from plots that received either 2 or 4 tons of limestone per acre were lower than yields from plots on which S and Zn had been applied. The residual effects of S did not significantly influence the yield in the final year of the investigation. Applying Zn significantly increased yields in 1978.

When the yields for all years were combined, only the Zn treatment proved to be significant (Table 4). However, consistently higher yields of rice were recorded on plots that received both Zn and S. Consistently lower yields of rice were obtained following the application of 2 or 4 tons of limestone per acre when Zn and S were not applied. The data indicate that on silt loam soils with pH values approaching neutrality, applying Zn and/or S should be considered in the overall fertility program for rice production.

The effects of limestone, S, and Zn applications on soil-Zn and leaf-Zn contents over a 4-year period are shown in Table 5. Applying Zn increased the combined 4-year average soil-Zn content at all limestone and S rates. The soil on all plots that did not receive Zn contained relatively low levels of extractable Zn. The data indicate that limestone and S treatments did not significantly influence amounts of soil-Zn extracted with the DTPA-TEA method. Applying Zn did not significantly increase leaf-Zn concentrations. However, consistently higher leaf-Zn concentrations were found in leaves from plants grown on plots that received Zn. Leaf-Zn concentrations varied considerably some years. This variation indicates that plant-tissue analysis to determine Zn concentrations may have certain inherent limitations when used as a diagnostic technique. Climatic conditions, particularly temperature and overcast days, are known to influence plant growth and subsequent uptake of Zn and other essential plant-nutrient elements. Some of the variation in leaf-Zn noted during the different years may have been due to varying climatic conditions.

The influence of soil reaction (pH) on rice yields is presented in Figure 1. The pH of the soil accounted for 45.67 percent of the variability in yield. The data show that when soil pH exceeded 7.0, rice yields were significantly reduced. Further significant yield decreases were obtained when the pH of Crowley silt loam was adjusted to 7.5 with dolomitic limestone.

The relationship between yield and Zn extracted from Crowley silt loam with the DTPA-TEA method is shown in Figure 2. Extractable Zn levels accounted for 42.19 percent of the variability in yield. A simple linear

Table 5.—Effects of limestone, sulphur, and zinc applied to Crowley silt loam on soil-zinc and leaf-zinc content (1975-78)

				Zinc content (ppm)[1]			
				No zinc applied		Zinc applied	
Limestone applied (Tons/Acre)	Sulphur treatment	Year	Soil pH (Range)	Soil Zn[2]	Leaf Zn[3]	Soil Zn[2]	Leaf Zn[3]
0	No S	1975	6.4-7.1	0.6	16	0.9	27
		1976	6.4-7.3	0.6	17	1.2	25
		1977	6.4-7.1	0.4	17	0.8	23
		1978	6.6-7.4	0.3	17	0.9	20
		4-year average:		0.5	17	1.0	24
0	S	1975	6.2-7.4	0.6	20	1.0	29
		1976	5.4-6.9	0.5	16	1.3	22
		1977	5.7-6.7	0.4	20	0.9	21
		1978	5.8-6.8	0.4	19	1.0	19
		4-year average:		0.5	19	1.0	23
2	No S	1975	6.8-7.6	0.7	17	0.9	26
		1976	6.7-7.7	0.7	16	1.4	20
		1977	6.3-7.7	0.4	17	0.8	27
		1978	7.1-8.0	0.4	18	0.9	22
		4-year average:		0.5	17	1.0	24
2	S	1975	6.7-7.8	0.8	23	0.9	32
		1976	5.9-7.3	0.6	20	1.3	31
		1977	5.8-7.5	0.5	19	0.7	23
		1978	5.9-7.5	0.4	18	1.0	19
		4-year average:		0.6	20	1.0	26
4	No S	1975	6.9-7.7	0.6	15	0.9	26
		1976	6.7-7.8	0.7	13	0.4	12
		1977	6.7-7.8	0.5	14	0.8	20
		1978	7.2-8.1	0.4	18	0.8	20
		4-year average:		0.5	15	0.8	20
4	S	1975	6.7-7.5	0.7	21	1.1	29
		1976	6.1-7.5	1.5	26	1.3	21
		1977	6.1-7.4	0.4	16	0.8	20
		1978	5.9-7.9	0.3	17	0.9	17
		4-year average:		0.8	20	1.0	22

	Zinc comparisons	
	$LSD_{.05}$ (ppm)	CV (%)
Soil zinc (combined)	0.2	16.9
Leaf zinc (combined)	8.0	22.7

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[1] Average of three replications.

[2] Zinc was extracted from soil with the DTPA-TEA method. Zinc content of filtrate was determined on an atomic absorption spectrophotometer.

[3] Leaf tissue was digested in a 3:1 mixture of HNO_3 and $HClO_4$.

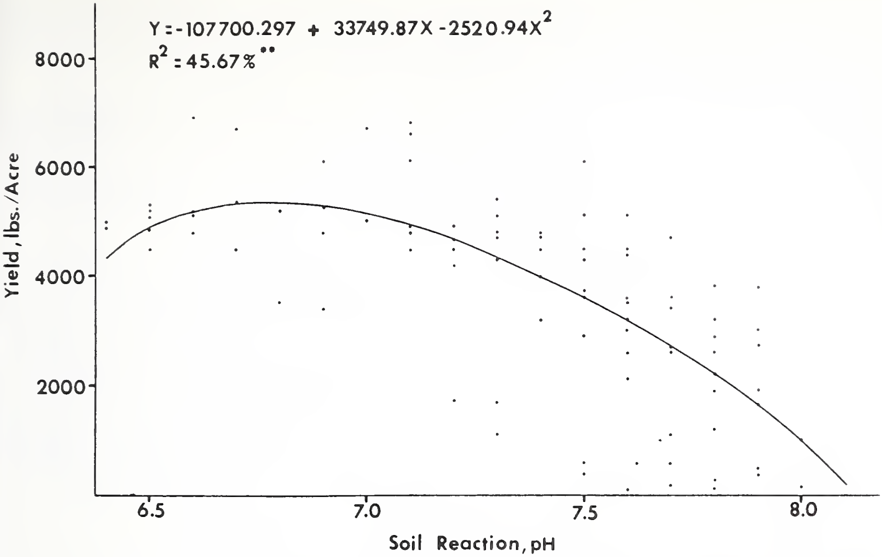

Figure 1.—Influence of Crowley silt loam soil reaction (pH) on rice yields. **P<.01.

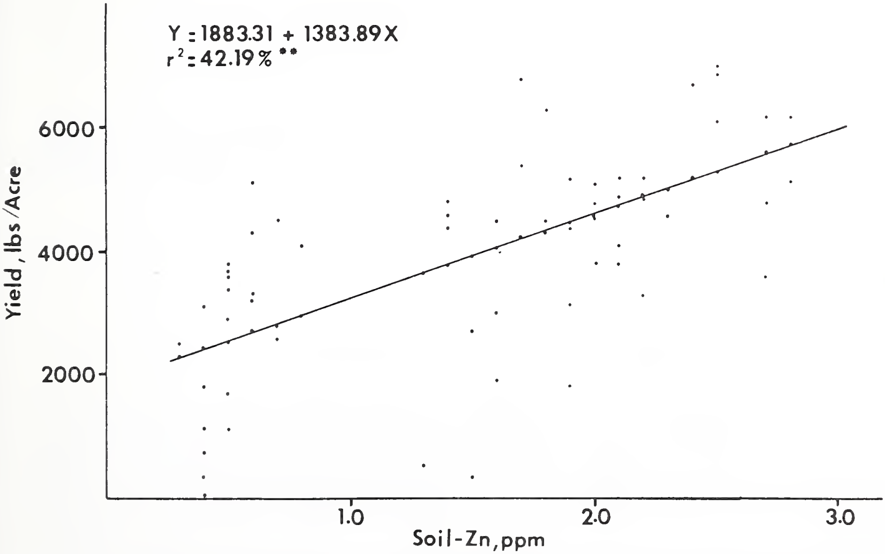

Figure 2.—Relationship between rice yields and zinc extracted from Crowley silt loam with the DTPEA-TEA method. **P<.01.

relationship was found between these two variables. The data show that rice yields were significantly lower on soils that did not receive Zn and contained less than 1.0 ppm of extractable Zn.

The influence of soil pH on soil-Zn levels is shown in Figure 3. The data show that increasing soil pH from 6.5 to 8.0 resulted in a significant linear reduction in soil-Zn amounts extracted with the DTPA-TEA method. Critically low soil-Zn levels were found when the pH was adjusted to 7.5 on soil to which no zinc had been applied.

The relationship between leaf-Zn concentrations and soil-Zn levels is shown in Figure 4. A highly significant curvilinear relationship was found between these two variables. Approximately 23 percent of the variability was accounted for in the regression analysis. The data indicate that extracting soil Zn with the DTPA-TEA method and determining leaf-Zn concentrations of leaves from rice plants with panicles that are 2-mm long may be effective diagnostic techniques to determine the Zn-nutrient status of soils and plants.

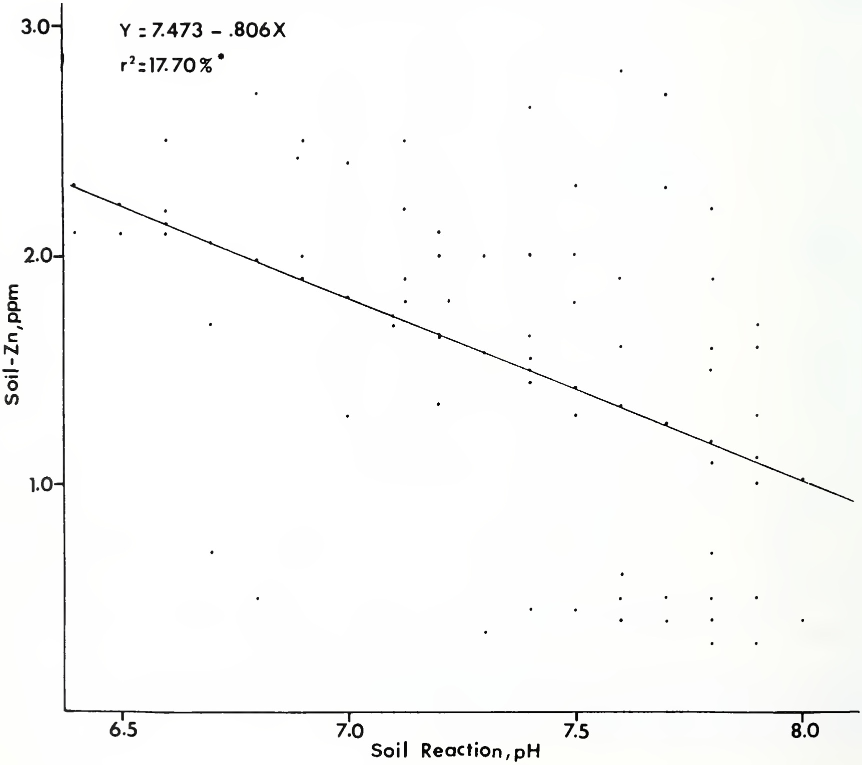

Figure 3.—Influence of soil reaction (pH) on zinc extracted from Crowley silt loam with the DTPA-TEA method. *P<.05.

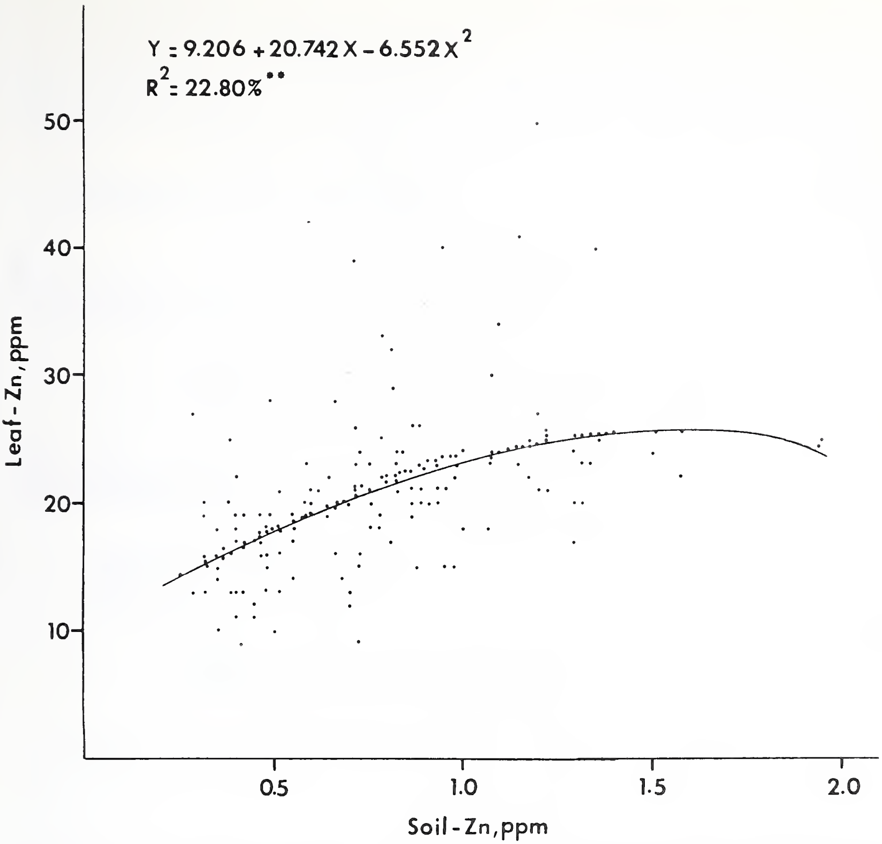

Figure 4.—Relationship between leaf-zinc concentration and zinc extracted from Crowley silt loam with the DTPA-TEA method. **P<.01.

Summary and Conclusions

An investigation conducted under field conditions determined the influence of different soil pH levels and annual Zn applications on rice yields, soil-Zn and leaf-Zn concentrations. Rice was grown on Crowley silt loam (Typic Albaqualf). Data obtained over 10 years led to the following conclusions:

1. A highly significant quadratic relationship was found between the rice yields and soil pH. Soil pH accounted for 45.67 percent of the variability in yields. Rice yields were significantly reduced when soil pH exceeded 7.0. Further significant yield decreases resulted when soil pH was adjusted to 7.5.

2. A highly significant linear relationship was found between yields and soil-Zn levels extracted with the DTPA-TEA method. Extractable Zn accounted for 42.19 percent of the variability in yield. Significantly lower rice yields were obtained on soils that did not receive supplementary Zn when these soils contained less than 1 ppm extractable Zn.

3. Increasing soil pH from 6.5 to 8.0 resulted in a significant linear reduction in the amount of soil Zn extracted with the DPTA-TEA method. Critically low soil-Zn levels were found when the soil pH was adjusted to 7.5 when no Zn was applied.

4. A highly significant curvilinear relationship was found between the Zn concentration of rice leaves and soil-Zn levels extracted with the DTPA-TEA method. Approximately 23 percent of the variability in leaf-Zn concentrations was accounted for by extractable soil-Zn levels.

5. Data indicate that the amount of soil-Zn extracted with the DTPA-TEA method and determining leaf-Zn concentrations of rice plants with panicles 2-mm long may be effective diagnostic techniques to determine the zinc-nutrient status of soils and rice plants.

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Clothing Expenditures Among the Expenditure Priorities of Elderly Couples Before and After Retirement

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The Louisiana Agricultural Experiment Station follows a nondiscriminatory policy in programs and employment.

Clothing Expenditures Among the Expenditure Priorities of Elderly Couples Before and After Retirement

ELEANOR KELLEY, JOAN GRAY, GLADYS J. HILDRETH,
MARIE GRAVOIS, AND REBECCA S. TURNER[1]

Introduction

When economist Kenneth Boulding addressed the annual meeting of the American Home Economics Association in 1970, he noted that the family, or household sector, of the economy is the most significant spending sector of the national economy, ranging over the years from 60 to 70 percent of the Gross Capacity Product *(1)*.[2] Austin H. Kiplinger, publisher of *Changing Times*, reiterated this importance, citing similar figures, during the annual meeting in 1975 *(2)*.

The elderly as one segment of the household (consumer) sector of the economy are increasing in significance. In 1977 there were 23,494,000 persons beyond the age of 65, and their number is expected to increase to 31,823,000 by the year 2000—a projected 35 percent increase in 23 years' time *(3)*. Previously, the later years of life were considered a static period, and all elderly were classified as one stereotyped group *(4)*. However, many elderly persons today have good health and physical vigor, and they also have sufficient economic security to have a comfortable life. Ages among the elderly may span two or three generations and within-group differences may be as great as the differences between the elderly and those under 65 years of age *(5)*. Researchers have found that elderly persons who remain socially active are more likely to adjust well to retirement than those individuals who do not *(6)*. As medical advances increase longevity and more individuals elect early retirement, the number of elderly people who remain socially active will probably continue to increase.

Focus

In the 1960's researchers found that although elderly consumers often had less income, they had "fluid" income. They had fewer family responsibilities, few debts, favorable tax exemptions, retirement plans, and sometimes mortgage-free homes. Consequently, they were free to spend their incomes as they saw fit *(7)*. Many changes have occurred in the economy in the intervening years. The elderly have been concerned with economic problems such as inflation *(8)*, failure of private pension plans *(9)*, fear of unavailability of social security funds in future years *(10)*, and rapidly rising taxes *(8)*. These economic difficulties can counteract the positive influences of fluid income and lack of responsibilities, and many elderly are locked into forced expenditure patterns.

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[2] Italicized numbers in parentheses refer to References Cited, page 14.

Life views among the elderly have also changed. Many have elected early retirement and continue to be socially active during a number of post-retirement years. Social participation is greatly influenced by self concept *(11)*, and one of the variables in the on-going socialization involved in drastic role changes such as those associated with retirement is personal appearance. Clothing has been found to be invaluable in establishing first impressions in new situations encountered with role changes *(12)*, in facilitating group acceptance *(13)*, in developing a satisfactory self concept *(14)*, and in successful role performance *(12)*, *(13)*, *(14)*.

One characteristic of the budgets of the elderly is a reduction in clothing expenditures *(14)*. If this reduction constitutes a discrepancy between their actual clothing expenditures and their ideal desires for clothing expenditures, this may be a factor in the social and psychological adjustment of the elderly to aging. This relationship between the economic and social-psychological variables in clothing behavior has long been recognized by researchers in agriculture *(15)* and home economics *(16)*.

The Problem

This exploratory study was designed to focus specifically on a group of socially active elderly with special emphasis on their clothing expenditures. Data were collected on the total range of expenditures, and this enabled consideration of (1) how the elderly consumers were allocating their total retirement dollars; (2) what changes, if any, they made in expenditures after retirement; (3) if they would allocate their money differently if they were free to do so; and, (4) in particular, how clothing expenditures fitted into these overall expenditures.

The Sample

At the time the study was planned more than 90 percent of the elderly in the United States were white, and almost 60 percent were female *(17)*. Although more than 50 percent of the women were widows, less than 15 percent of the men were widowers *(17)*. Therefore, to insure male participation, the decision was made to study white, intact couples who remained socially active and responsible for maintaining their own homes during their retirement years. Since approximately one out of every six elderly existed on an income well below the poverty level *(18)*, an attempt was also made to get a cross-section of economic levels among the couples in the sample.

Pronounced cultural differences exist in Louisiana *(19)*; therefore, interviews were conducted with 45 couples in one parish in south Louisiana (in 1977) and 36 couples in one parish in north Louisiana (in 1978). Both of these parishes were known to include a number of low-income elderly. Although they were mainly rural parishes, both were within driving distance of large cities where the residents were employed or shopped. The southern parish had three towns with populations of more than 1,000 residents, and the northern parish had one town this large. Couples were interviewed in each of these towns and in the surrounding areas included in the mailing zip codes for each of these towns. This included town, rural non-farm, and farm residents in the sample. (See the Appendix for additional description of sample selection.)

Profile of Respondents

Stafford, as part of a Cornell University project, found a number of demographic variables affected the overall expenditures of the elderly families in her New York State study. These included total household income, net changes in assets and liabilities, tenure (owning or renting), age of the head of household, age composition of the family, family size, race, number of earners, earner composition, education, stratum size, and medical care expenditures. The underlined variables were related to their clothing expenditures. Location of residence (rural-urban), medical expenses, increased bills, and savings also affected clothing expenditures *(20)*.

An attempt was made with median tests to determine similar relationships among the couples in the current study. The data were also programmed on chi square tables to determine if the percentages in the chi square cells formed a meaningful pattern related to selected demographic and activity variables. For example, with the special focus on clothing, the cells were checked to see if changes in activities coincided with changes in clothing types or in usage of various fibers, garment designs, and fasteners. The data did not form meaningful patterns, even when logical units for collapsing the chi square cells were employed. Therefore, this set of analyses was deleted, and the demographic and activity data are reported only in the following profile of the respondents.

Although all of the men were retired, only 84 percent of them and 56 percent of their wives were 65 years old or older. The majority of the men (61 percent) were between 65 and 74 years old. Of the remainder, 23 percent were 75 or older, and 13 percent were under 65. More of the wives were younger with 44 percent under 65 years of age. Only 48 percent were between 65 and 74, and 8 percent were 75 or older. Most of the couples (95 percent) had children. One couple did not have full responsibility for maintaining their home, and three couples did not participate alone in such activities as purchasing groceries, visiting relatives, and attending church. Among the couples, 32 percent of the husbands and 31 percent of the wives had increased the amount of time they spent in such activities, while 25 percent of the husbands and 28 percent of the wives had decreased the time spent in such activities. Seventy-five percent of the couples were devoting their post-retirement time to the same kinds of activities in which they engaged prior to retirement, but slightly more than 50 percent of them had changed the number of activities in which they participated. This percentage was almost equally divided between those who had increased (30 percent, husbands; 26 percent, wives) and decreased (26 percent, husbands; 30 percent, wives) the number of activities after retirement.

The educational backgrounds of the husbands and wives ranged from less than elementary education through college degrees. However, the husbands' pre-retirement occupations clustered more in the middle ranks of skilled labor and clerical positions. As ranked according to the seven-point index of Hollingshead's *Two Factor Index of Social Position (21),* 75 percent clustered in levels three, four, and five, including skilled labor, clerical and sales, and minor professionals. Of the remainder, 11 percent ranked in levels one and two, the highest executive and professional ranks; and 14 percent in level six, the lower level of semi-skilled labor. None was ranked in seven, the lowest level of unskilled or unemployed workers. When the husbands' education and occupation rankings were combined according to Hollingshead's formula, 69 percent of the couples were considered middle social class; 21 percent, lower; and 10 percent, higher social class.

Fifty-seven percent of the couples had changed expenses at retirement. Of these couples, 47 percent had eliminated some expenses and 20 percent had added some expenses. Although only 36 percent of them had made changes in the types of clothing worn, one might expect them to consider changes in clothing expenses as a part of the overall budget changes initiated after retirement.

Measures of Expenditures

The researchers expected some of the respondents to have poor eyesight or limited reading comprehension. Therefore, each of the expense categories was presented on a different colored flash card. The Bureau of Labor Statistics (BLS) family budgets expense categories *(22)* were used as a basis to develop the categories. Several categories in the BLS "other" category were treated as separate categories, and savings, hereafter referred to as an expenditure category, was added.

The interviewer first directed each couple as a family unit to select cards representing their current expenditures. Then they were asked to place each card chosen on a lap board in the order of its priority among their expenses. Each couple completed a total of six arrangements—actual and ideal pre-retirement expenditures, actual and ideal post-retirement expenditures, and projected changes in expenditures if the family income were increased $100 per month and if it were decreased $100 per month. When each new set of arrangements was requested, all of the original 10 cards were returned to the stack so the couple could add and delete expenditures as appropriate for each arrangement. Their assessments of the ranking of each expenditure on each arrangement were recorded by the interviewer on a checksheet.

All of the couples did not rank the same number of expenditures on each arrangement, and some of the couples ranked different numbers of expenditures on the various budget arrangements. These unequal rankings influenced the statistics chosen for data analysis. (See the Appendix for additional explanation of statistical choices.)

Actual Post-Retirement Priorities

As shown in Table I,[3] most of the couples had seven of the ten expenditure categories in their budgets. *Clothing* was assigned a lower priority than four of these expenses, *food, housing and household, transportation,* and *medical care,* by enough of the couples to produce highly significant differences in the couples' priorities for *clothing*. *Clothing* was also ranked lower than *insurance* by the majority, but this frequently merely bordered on significance. *Clothing* was ranked higher than *personal care* and *other consumption*[4] by the majority of the respondents. The number who ranked *clothing* higher than *personal care* was sufficient to produce a highly significant difference, but the number who ranked *clothing* higher than *other consumption* was not.

Savings was included in the budgets of approximately half of the couples. *Clothing* was ranked lower than *savings* by the majority, but this difference only bordered on significance.

Only a few couples still had *educational expenses* and *financial aid to children*, but 75 percent of those who did assigned *clothing* a lower priority than each of these expenses.

Ideal Post-Retirement Priorities

The couples were also asked how they would allocate their funds if they were free to spend their incomes according to personal desires. As shown in

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[3] All tables in Appendix.

[4] Many of the couples told the interviewers that they did not have recreational or entertainment expenses, expenses in the *other consumption* category, because they could not afford such luxuries. However, especially in the southern parish, most of the couples "tithed" 10 percent of their income to the church, and religious contributions constituted the bulk of their *other consumption* category.

Table II, their ideal arrangements of the expenditure cards produced results similar to their actual arrangements. The majority still ranked *clothing* lower than *food, housing and household, transportation, medical care,* and *insurance,* and all were highly significant differences; however, the number who ranked *clothing* lower than *medical care* decreased slightly from the actual to the ideal arrangement. Although the number who ranked *clothing* lower than *insurance* on the actual arrangement was insufficient to be a significant difference, the number who ranked it lower on this ideal arrangement was sufficient to be a significant difference.

More than 80 percent also continued to place a higher priority on *clothing* than on *personal care,* resulting in a highly significant difference. Only two other expenditures were ranked in sufficient numbers to enable statistical calculations. On this ideal arrangement, a few more than on the actual arrangement ranked *clothing* lower than *other consumption* expenditures, and a few more ranked *clothing* higher than *savings.* However, these differences were still not significant differences.

Discretionary Income

The researchers believed that freedom to assign priorities to expenditures was partially dependent upon having some discretionary income; otherwise, there would be no room for priority changes to meet the couples' personal desires. Couples were asked to indicate the amount of their monthly discretionary income, classified as high or low amounts based on BLS hypothetical family budgets for retired elderly couples. As shown in Table III, amount of discretionary income was not a significant source of variation in the couples' priorities for *clothing* on their actual budget arrangements, their ideal budget arrangements, and their *clothing* variants. The *clothing* variants represented the numerical difference between the ranks assigned to *clothing* in the actual and in the ideal expenditure arrangements. As shown in Table IV, the variant mean score for the high discretionary income group was a negative number, suggesting that many of the couples in the high income group ranked *clothing* lower on their ideal arrangement than on their actual arrangement.

Pre- and Post-Retirement Clothing Expenditures

Sociologist Gregory Stone, who has been interested in the role of appearance in daily life, notes that a change in dress frequently accompanies a major change in an individual's life *(23).* This implies a change in expenditures, since acquiring new clothing is expensive.

As shown in Table V, no significant differences occurred in all three types of *clothing* expenditure priorities. But, as the mean scores in Table V show, the couples did assign higher ranks to *clothing* in the post-retirement arrangements. The difference in mean scores is especially noticeable in the *clothing* variant score, and the pre-retirement variant mean score was a negative number, indicating that many of the couples ranked *clothing* lower on their ideal arrangement than on their actual arrangement.

Additional Pre- and Post-Retirement Expenditures

Although the major thrust of this study was to compare *clothing* to other expenditures, data were collected on all expenditures. When the same analysis format used with *clothing* was used to look at the couples' actual expenditures before and after retirement for each of the remaining nine categories, again no significant differences occurred (Table VI). The mean scores suggest that those who ranked each of the items assigned slightly higher post-retirement than pre-retirement priorities to their expenditures for *personal care, transportation, savings,* and *financial aid to children.* Conversely, they assigned slightly lower post- than pre-retirement priorities to *food, housing and household, medical care, insurance,* and *other consumption* expenditures. The few who ranked *education* expenses ranked it the same on both budgets

Actual Pre-Retirement Priorities

The couples were asked to recall their pre-retirement expenditure priorities so they could be compared with their post-retirement expenditure priorities as was done in Tables V and VI. It was, therefore, possible to determine the relative rank of *clothing* among their pre-retirement priorities as was done for their post-retirement priorities (reported in Table I). The same eight expenditure categories were ranked by a sufficient number of couples to produce meaningful pre-retirement data. As shown in Table VII, *clothing* was ranked lower than *food, housing and household,* and *transportation* by a sufficient number to produce highly significant differences. Although *clothing* was ranked lower than *medical care* by enough respondents in their post-retirement arrangements to produce a highly significant difference (Table I), there was only a significant difference in their pre-retirement rankings (Table VII).

Pre-retirement *clothing* expenditures were ranked significantly higher than *personal care, savings, other consumption,* and *financial aid to children* (Table VII). These are the same rank directions as on their actual post-retirement arrangements (Table I). Conversely, *clothing* was ranked lower than *insurance* on this pre-retirement arrangement (Table VII), but it was ranked higher on the post-retirement arrangement (Table I).

Ideal Pre-Retirement Priorities

The interviewers asked the couples how they would have liked to spend their incomes before retirement. Again, it was possible to determine the relative rank of *clothing* among their ideal pre-retirement expenditures as was done for their ideal post-retirement priorities (reported in Table II).

The couples continued in their ideal pre-retirement expenditure arrangements (Table VIII) to rank *clothing* lower than *food, housing and household, transportation, medical care,* and *insurance* expenditures as they did on their actual pre-retirement expenditure arrangements (Table II). All of these expenditure priorities were still significantly different except the *insurance* expenditure. The number who ranked *clothing* lower than *insurance* on the actual arrangement decreased sufficiently on this ideal arrangement to negate a significant difference.

The couples also continued to rank *clothing* higher than they ranked *personal care, financial aid to children,* and *savings* on their ideal and actual pre-retirement expenditures. Their rankings yielded highly significant differences between *clothing* and *personal care* on both pre-retirement arrangements, and rankings of *clothing* and *financial aid to children* yielded a significant difference on both arrangements. Rankings of *clothing* and *savings* yielded a significant difference on only the actual pre-retirement arrangement.

The couples' *clothing* and *other consumption* expenditure rankings followed the same pattern on the actual and ideal pre-retirement arrangements. More of them ranked *clothing* higher than *other consumption* on both arrangements. This difference in *clothing* and *other consumption* rankings on the ideal arrangement was sufficient to be a significant difference, and on the actual arrangement it was a highly significant difference (all numbers reported in Table VIII).

Summary of Expenditure Arrangements

Clothing was ranked significantly lower than *food* and *housing and household* expenditures on all of the budget arrangements by most of the couples. Approximately the same number ranked *clothing* lower than *transportation* and *medical care* on all of the arrangements, but a slightly larger number ranked *clothing* lower than *transportation* on some budget arrangements, and a greater number ranked *clothing* lower than *medical care* on others.

The one expenditure ranked significantly lower than *clothing* on all of the budget arrangements was *personal care.*

Two expenditures, *education* and *financial aid to children*, were omitted from all expenditure arrangements by most of the couples. Those who included these expenses ranked them as low priority expenditures.

Comparison With BLS Budgets

The decrease in *clothing* expenditures in later years often has been attributed to a waning interest in personal appearance. Some researchers disagree with this stereotyped view. When appearance standards decrease among the elderly, it is often due to physical or mental health losses or lack of money *(14), (24).*

The hypothetical BLS budgets include adjustments for selected economic differences and regional and climatic differences. However, they do not consider activities and health status of the elderly. Since this study included only socially active elderly, the researchers decided to compare their expenditures with the BLS categories. The researchers were most interested in clothing, but they utilized all of the comparative data.

The couples were presented a flash card with the hypothetical BLS income levels and were asked to assess their personal income as within the high, intermediate, or low ranges of the BLS budgets. Only two expenditure categories, *food* and *transportation,* were ranked the same as the BLS rankings by at least 30 percent of the couples. These categories were the only ones in which significant differences were not present for all income levels (see Tables IX and X.) No significant difference was found in the BLS rankings and pre-retirement rankings of the lower income respondents for *food,* and the differences in their post-retirement rankings of *food* and *transportation* were merely marginal ($P<.0548$).

As noted in Tables IX and X, most of the differences between the couples' and the BLS *clothing* rankings of pre- and post-retirement arrangements occurred because the majority of the couples assigned higher priorities to *clothing,* with one exception. Almost half of the lower income level couples assigned *clothing* a ranking lower than the suggested BLS ranking, but only in their pre-retirement expenditures.

The majority of the couples at all income levels ranked *personal care* lower than the BLS did on their pre-retirement budget arrangements, but they ranked it higher on their post-retirement arrangements.

The couples' pre- and post-retirement rankings for *food* and *housing and household* expenses formed a consistent pattern for all income levels. Most of the respondents ranked *food* lower than the suggested BLS rankings on all budget arrangements, and most of them ranked *housing and household* expenditures higher than the suggested BLS rankings.

Most of the couples in the higher and intermediate income levels ranked *transportation* higher than the BLS did on their post-retirement expenditure arrangement, whereas most of those in the lower income level ranked it lower.

With two exceptions, the couples ranked *medical* expenses higher than the BLS suggested ranks. More of the intermediate and lower income couples ranked *medical* expenses lower than the BLS ranks, but only on their post-retirement arrangements.

Measuring Clothing Changes

A significant number of the couples changed their rankings of clothing expenditures after retirement. The researchers were interested in what types of clothing changes, if any, were involved in these expenditure changes. The types of clothing, fibers, and fasteners presented in Table XI include those recognized as necessary when the physical or mental handicaps often associated with aging necessitate simplification in construction or care features of clothing *(14)*. As shown in Table XI, highly significant differences among those couples who had and had not made changes occurred in most of the response categories. The majority of the couples who responded to each clothing, fiber, and fastener category listed reported the same amount of use after retirement, even though many did change their rankings of *clothing* among all of their expenditure priorities.

Summary and Conclusions

The convention theme in 1970 when Kenneth Boulding pinpointed the importance of consumers in the economy was "The Family Faces Change" *(1)*. The importance of this theme has become more pronounced for all families in the intervening years, but the elderly have especially experienced change as inflation and intermittent recessions have eroded the buying power of their fixed incomes. This study focused on a major change in the lives of the couples interviewed—the change to retirement status—and the implications of this change in their expenditure decisions.

Most of the couples said they would not change their spending patterns if given the opportunity. Their spending habits had evolved over a period of years, and they could not conceive of spending money in any other fashion. This habitual behavior was reflected in their clothing choices; few made changes in the types of clothing, fibers, or fasteners used. However, many said that the total dollars spent on categories such as *clothing* and *food* had decreased dramatically since retirement, and their priorities for these two expenditures had changed after retirement. *Clothing* was assigned a higher post-retirement priority in many budgets, but *food* was assigned a lower post-retirement priority.

In many cases, the couples' retirement coincided with termination of child support. Most had also paid for their houses. These reduced expenses may have enabled the increased emphasis on *clothing* expenditures. However, some of their expenses, such as *medical* expenses, rose drastically after retirement. This may have more than compensated for reduced child support and housing expenses. Although only active couples were interviewed, most reported that at least one of them had been seriously ill, frequently requiring hospitalization. Medicare prevented them from experiencing financial disaster, but most still had high monthly medical expenses, some of which were lifetime necessities. Ranking *clothing* higher in such a situation pinpoints the importance of personal appearance to these couples.

One interesting aspect, mostly in the southern parish, was an extensive bartering system. Many of the couples were given many of the items they used, primarily clothing. Almost all of them had gardens. The gardens provided them with fresh vegetables in season and surplus to can or freeze and to give away. In addition to the personal satisfaction gained from their gifts, most reported receiving other goods and services in return, especially clothing. These bartered goods were not included in the couples' income or expenditures, yet they did increase their real income and consequent purchasing power. The setting for the study, a temperate climate with sufficient land for almost year-round gardens, maximized the potential for gardens and bartering as avenues for increased purchasing power. This was reflected when their rankings were compared to the suggested BLS rankings. *Food* ranked consistently lower at all income levels, but *clothing* ranked higher even though it was a commodity received in bartering.

The observations of other researchers that health and activities of the elderly influence their emphasis on personal appearance were also reflected in the data. *Clothing* and *personal care* expenditures were ranked higher than the suggested BLS ranks by the couples at all income levels on their post-retirement arrangements, whereas many had assigned these expenditures lower priorities than the BLS-suggested ranks on their pre-retirement arrangements. This increased emphasis is further magnified when the variable of bartering for clothing is considered. Medical problems seemingly did not negate these couples' having sufficiently active lives to maintain their homes and their interest in personal appearance. Only on the post-retirement arrangements of the intermediate and lower income couples was *medical care* assigned a lower rank than the BLS suggests. Yet *clothing* was assigned higher ranks than the BLS suggests by all income levels on all budget arrangements, and the couples had not made some of the clothing, fiber, and fastener changes that often accompany the infirmities of later years.

The couples told the interviewers when hypothetical increased incomes were posed that they would not change their spending patterns if given the opportunity, but many of them *had* made changes. Conceivably, economic circumstances may continue to force them to make additional undesired changes. They were also still active. As they develop the increased infirmities associated with advancing age, they may have to make additional changes in their expenditures as well as the design of their clothing.

The wide age span among the couples studied suggests that expenditure differences within the elderly segment of the population may be a matter of health rather than age. The importance of *clothing* in the hierarchy of expenditures may also be a function of health rather than age.

The size of this sample prohibited controlling for length of time since retirement. If indeed changes evolve over time, changes in *clothing* and other expenditures may evolve over time even among active elderly. Research with larger samples will be necessary to establish or refute these contentions.

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Appendix: Research Notes and Tables

Research Notes

This study was exploratory. Therefore, the sampling decisions and statistical choices were limited both by size of exploration and focus of study. The following discussion is designed for researchers who are interested in building on the current study to obtain more in-depth knowledge of the clothing expenditures of the elderly.

Sample Selection

One of the problems in interviewing the elderly is their apprehension of strangers. Therefore, to establish rapport, the parishes chosen were among those in which Cooperative Extension, in cooperation with parish Councils on Aging, had conducted extensive surveys. In the pilot for the current study, conducted in a third parish, lists from these previous surveys were used, and only those who stated they lived alone and maintained their activities were contacted. Very few blacks and single women or men responded to the mail-out questionnaire requesting their participation, and many on the list were either deceased or no longer active. Therefore, the decision was made to limit the final sample to intact white couples who were socially active. This limited the pool of potential respondents but resulted in a sample with certain dimensions of homogeneity. This was deemed more desirable than having some respondents whose characteristics were different in a small exploratory study.

For the final sample, current lists of elderly were provided by the two parish Councils on Aging and the Cooperative Extension home economists. Letters were mailed to all of the white couples on these lists who lived within the zip codes of the towns with populations of more than 1000. They were asked to return the enclosed brief questionnaires to verify their suitability for the sample and to sign them to indicate their positive response. Questions included marital status, ages, retirement status, location of home, ability to be active, and possible interview times. The 81 couples who met all of these criteria were interviewed. Some who responded affirmatively were either too young (under 60), not retired, or unable to maintain their activities and homes, and they were eliminated. The few couples in which one spouse was inactive were retained.

Statistical Choices

All of the couples did not rank the same number of expenditures on each arrangement, and some of the couples ranked different numbers of expenditures on the various arrangements. These variations in number of expenses ranked caused the absolute ranks of each expense to represent different priority weights among couples or among the different arrangements of a given couple. For example, if one couple ranked only seven and another ranked all 10 expenses, but both ranked *clothing* fifth, the relative priority weights of *clothing* in the two budgets would be different. These differing n's precluded using certain statistics. Non-parametric correlations such as the Kendall Coefficient of Concordance or Spearman Rho require precisely the same n's on both variables ranked *(25)*. Contingency coefficient, based on chi square, does not take order into account. The same problem of empty chi square cells, noted in the discussion of the description of respondents, was present with contingency coefficient.

Tables I, II, VII, and VIII include data regarding ranking of *clothing* in relation to the couples' priorities for their other expenditures in the actual and the ideal pre- and post-retirement arrangements. The binomial test was used to determine whether differences existed between the couples' priorities for their *clothing* expenditures and their other expenditures in each arrangement. This was accomplished by computing the frequency of the rank assigned to each of their other expenditure categories in relation to the rank each couple assigned to the *clothing* expenditures. The probability table available for the binomial test was designed for a one-tailed test of significance *(25)*. These probability levels were doubled to give the two-tailed levels of significance reported.

Tables III and IV show the findings regarding actual and ideal *clothing* expenditures as related to discretionary income. The data were subjected to analysis of variance with ranks of expenditures as the covariable. The covariable was necessary to remove the individual differences in the couples' *clothing* expenditure rankings that resulted from their ranking different numbers of the 10 expenditure categories.

Tables V and VI contain the data regarding the actual and ideal *clothing* expenditures of these couples before and after retirement with analysis of covariance with expenditure ranks as the covariable. However, for ease of reporting, significant differences between pre-retirement and post-retirement treatments were derived from a paired t-test since $t = \sqrt{F}$ with one degree of freedom in the numerator.

Tables IX and X show the frequency distributions and resulting probability levels from binomial tests comparing the couples' ranks with suggested BLS ranks for each expenditure included. Only six expenditure categories were included in this study in precisely the same way as they were in the hypothetical BLS budgets. Several *other consumption* expenses were separated as additional categories; therefore, it was impossible to compare the *other consumption* data. To create binomial categories, it was necessary to combine those who ranked an expense higher with those who ranked it lower than the BLS rankings. However, this still enabled consideration of differences between the couples' and the BLS rankings. It was also possible to look at percentages within the binomial grouping of those whose ranks were different from the BLS ranks to see if most of them ranked a category higher or lower than the BLS rank.

This same problem of creating two categories for binomial analysis is noted in Table XI in which changes in types of clothing, fibers, and fasteners are reported. Again, the binomial enabled measurement of change, and it was possible to look at percentages to see whether the change in each item was an increase or decrease in usage.

Table I. Post-retirement rankings of actual clothing expenditure priorities of selected Louisiana elderly couples in 1977-78 compared with rankings of each expenditure category with binomial tests

Expenditure categories	Total numbers who included expenditure categories	Assigned priority lower than clothing		Assigned priority higher than clothing	
		n	%	n	%
Personal care	72	61	84.72	11	15.28****
Financial aid to children	8	6	75.00	2	25.00
Other consumption	74	41	55.40	33	44.60
Savings	47	30	63.83	17	36.17[a]
Housing and household	76	10	13.16	66	86.84****
Insurance	71	28	39.44	43	60.56[a]
Food	78	1	1.28	77	98.72****
Transportation	78	14	17.95	64	82.05****
Medical care	76	15	19.74	61	80.26****
Education	4	3	75.00	1	25.00[b]

****.0001 level of significance.

[a] Borders on significance between .05 and .10.

[b] No test because of small n.

Table II. Post-retirement rankings of ideal clothing expenditure priorities of selected Louisiana elderly couples in 1977-78 compared with rankings of each expenditure category with binomial tests

Expenditure categories	Total numbers who included expenditure categories	Assigned priority lower than clothing n	%	Assigned priority higher than clothing n	%
Personal care	70	59	84.29	11	15.71****
Financial Aid to children	9	7	77.78	2	22.22
Other consumption	73	36	49.32	37	50.68
Savings	48	28	58.33	20	41.67
Housing and household	75	10	13.33	65	86.67****
Insurance	70	26	37.14	44	62.86*
Food	78	1	1.28	77	98.72****
Transportation	77	15	19.48	62	80.52****
Medical care	75	20	26.67	55	73.33****
Education	4	3	75.00	1	25.00[a]

*.05 level of significance.

****.0001 level of significance.

[a] No test because of small n.

Table III. Analysis of variance, with covariable for correcting number of items ranked, for differences between post-retirement actual clothing expenditure priorities, ideal clothing expenditure priorities, and clothing variants by discretionary income of selected Louisiana elderly couples in 1977-78

Types of clothing expenditure priorities and sources of variation	d.f.	Mean squares	F values[a]
Actual clothing expenditure priorities			
Discretionary income	1	0.2074	.07
Covariable	1	4.5402	1.56
Error	73	2.9135	
Ideal clothing expenditure priorities			
Discretionary income	1	0.9982	.34
Covariable	1	8.2598	2.83
Error	73	2.9198	
Clothing variants			
Discretionary income	1	0.0327	.01
Covariable	1	13.2874	2.90
Error	17	4.5826	

[a] No significant differences.

Table IV. Adjusted means for correcting number of items ranked for post-retirement actual clothing expenditure priorities, ideal clothing expenditure priorities, and clothing variants by discretionary income of selected Louisiana elderly couples in 1977-78

Discretionary income	Types of clothing expenditure priorities					
	Actual		Ideal		Variant	
	n	Mean	n	Mean	n	Mean
High	43	5.7657	42	5.7450	9	−0.0467
Low	33	5.8810	34	5.9914	11	0.0382

Table V. Adjusted mean scores and t-test values for differences between pre-retirement types of clothing expenditure priorities and post-retirement types of clothing expenditure priorities of selected Louisiana elderly couples in 1977-78

Types of clothing expenditure priorities	n	Adjusted mean scores		t^a
		Pre-retirement	Post-retirement	
Actual clothing expenditure priorities	77	5.31	5.83	3.2109^b
Ideal clothing expenditure priorities	75	5.40	5.84	2.7092
Clothing variants	76	−0.05	1.45	8.2813

[a] $t = \sqrt{F}$ with 1 d.f. in the numerator.
[b] No significant differences.

Table VI. Adjusted mean scores and t-test values for differences between actual pre-retirement expenditure and savings categories and actual post-retirement expenditure and savings categories, excluding clothing, of selected Louisiana elderly couples in 1977-78

Expenditure and savings categories	Total numbers who included expenditure categories in both pre- and post-retirement rankings	Mean scores		t^a
		Pre-retirement	Post-retirement	
Personal care	147	7.45	7.51	$.7615^b$
Financial aid to children	15	7.88	8.50	1.2569
Other consumption	151	6.22	6.18	.2645
Savings	93	6.45	6.60	.5099
Housing and household	155	3.49	3.47	.1000
Insurance	145	5.22	4.86	1.9874
Food	161	1.30	1.75	.7280
Transportation	161	3.62	3.63	.1000
Medical care	155	4.45	3.62	4.0779
Education	5	7.67	7.67	—

[a] $t = \sqrt{F}$ with 1 d.f. in the numerator.
[b] No significant differences.

Table VII. Pre-retirement rankings of actual clothing expenditure priorities of selected Louisiana elderly couples in 1977-78 compared with rankings of each expenditure category with binomial tests

Expenditure categories	Total numbers who included expenditure categories	Assigned priority lower than clothing		Assigned priority higher than clothing	
n	%	n		%	
Personal care	72	63	87.50	9	12.50****
Financial aid to children	7	7	100.00	0	0.00*
Other consumption	74	49	66.22	25	33.78**
Savings	48	32	66.67	16	33.33*
Housing and household	75	14	18.67	61	81.33****
Insurance	70	36	51.43	34	48.57
Food	77	3	3.90	74	96.1 ****
Transportation	77	18	23.38	59	76.62****
Medical care	74	27	36.49	47	63.51*
Education	8	4	50.00	4	50.00

*.05 level of significance.
**.01 level of significance.
****.0001 level of significance.

Table VIII. Pre-retirement rankings of ideal clothing expenditure priorities of selected Louisiana elderly couples in 1977-78 compared with rankings of each expenditure category with binomial tests

Expenditure categories	Total numbers who included expenditure categories	Assigned priority lower than clothing		Assigned priority higher than clothing	
		n	%	n	%
Personal care	71	63	88.73	8	11.27****
Financial aid to children	7	7	100.00	0	0.00****
Other consumption	72	46	63.89	26	36.11*
Savings	49	29	59.18	20	40.82
Housing and household	74	15	20.27	59	79.73****
Insurance	70	34	48.57	36	51.43
Food	76	3	3.95	73	96.05****
Transportation	76	18	23.68	58	76.32****
Medical Care	73	28	38.36	45	61.64*
Education	8	4	50.00	4	50.00

*.05 level of significance.
****.0001 level of significance.

Table IX. Pre-retirement rankings of actual expenditure priorities of selected Louisiana elderly couples in 1977-78 compared with BLS rankings with binomial tests

Expenditure categories by BLS rankings	Total numbers who included expenditure categories	Assigned same priority as BLS		Assigned different priority from BLS[a]			
				Higher		Lower	
		n	%	n	%	n	%
Higher							
Housing and household	30	3	10.0	27	90.0	0	0.0****
Food	30	7	23.3	7	23.3	16	53.3**
Transportation	30	9	30.0	10	33.0	11	37.0*
Medical care	27	5	19.0	20	74.0	2	7.0**
Clothing	30	5	17.0	16	53.0	9	30.0**
Personal care	28	1	4.0	11	39.0	16	57.0****
Intermediate							
Housing and household	20	5	25.0	15	75.0	0	0.0*
Food	21	4	19.0	5	24.0	12	57.0**
Transportation	21	5	23.8	10	47.6	6	28.6*
Medical care	21	4	19.0	9	43.0	8	38.0**
Clothing	20	3	15.0	11	55.0	6	30.0**
Personal care	21	0	0.0	8	38.0	13	62.0****
Lower							
Housing and household	25	3	12.0	22	88.0	0	0.0**
Food	27	9	33.0	3	11.0	15	56.0
Transportation	27	7	26.0	8	30.0	12	44.0*
Medical care	27	6	22.0	11	41.0	10	37.0**
Clothing	24	5	21.0	9	37.0	10	42.0**
Personal care	23	5	22.0	6	26.0	12	52.0**
Combined							
Housing and household	75	11	15.0	64	85.0	0	0.0****
Food	78	20	26.0	15	19.0	43	55.0****
Transportation	78	21	27.0	28	36.0	29	37.0****
Medical care	75	15	20.0	40	53.0	20	27.0****
Clothing	74	13	17.0	36	49.0	25	34.0****
Personal Care	72	6	8.0	25	35.0	41	57.0****

*.05 level of significance.

**.01 level of significance.

****.0001 level of significance.

[a] Categories combined to calculate binomials.

Table X. Rankings of actual expenditure priorities of selected Louisiana elderly couples in 1977-78 according to BLS rankings by post-retirement status and probability levels resulting from binomial tests

Expenditure categories by BLS rankings	Total numbers who included expenditure categories	Assigned same priority as BLS		Assigned different priority from BLS[a]			
				Higher		Lower	
		n	%	n	%	n	%
Higher							
Housing and household	31	1	3.0	30	97.0	0	0.0****
Food	31	5	16.0	8	26.0	18	58.0**
Transportation	31	8	26.0	14	45.0	9	29.0**
Medical care	29	4	14.0	14	48.0	11	38.0**
Clothing	31	7	22.5	20	64.5	4	13.0**
Personal care	31	3	10.0	25	80.0	3	10.0****
Intermediate							
Housing and household	20	3	15.0	17	85.0	0	0.0**
Food	21	2	9.0	5	24.0	14	67.0**
Transportation	21	5	24.0	9	43.0	7	33.0*
Medical care	21	4	19.0	7	33.0	10	48.0**
Clothing	20	5	25.0	12	60.0	3	15.0*
Personal care	21	1	5.0	19	90.0	1	5.0****
Lower							
Housing and household	25	3	12.0	22	88.0	0	0.0**
Food	27	8	30.0	3	11.0	16	59.0[b]
Transportation	27	8	30.0	7	26.0	12	44.0[b]
Medical care	27	3	11.0	11	41.0	13	48.0****
Clothing	24	5	21.0	13	54.0	6	25.0**
Personal care	20	2	10.0	15	75.0	3	15.0**
Combined							
Housing and household	76	7	9.0	69	91.0	0	0.0****
Food	79	15	19.0	16	20.0	48	61.0****
Transportation	79	21	27.0	30	38.0	28	35.0****
Medical care	77	11	14.0	32	42.0	34	44.0****
Clothing	75	17	23.0	45	60.0	13	17.0****
Personal care	72	6	8.0	59	82.0	7	10.0****

*.05 level of significance.
**.01 level of significance.
****.0001 level of significance.

[a] Categories combined to calculate binomials.
[b] Borders on significance at .06.

Table XI. Significant differences in selected Louisiana elderly couples' pre- and post-retirement usage of types of clothing, fibers, and fasteners, in 1977-78 as derived with binomial tests

Types of clothing, fibers, fasteners	Total numbers who included expenditure categories	Reported same amount of use		Reported different amount of use			
				Greater pre-retirement use		Less pre-retirement use	
		n	%	n	%	n	%
Wife's clothing:							
Dressy clothes	33	24	73.0	2	6.0	7	21.0**
Casual clothes	62	50	81.0	7	11.0	5	8.0****
Work clothes	30	20	67.0	9	30.0	1	3.0
Husband's clothing:							
Dressy clothes	32	21	66.0	1	3.0	10	31.0
Casual clothes	51	35	69.0	12	23.0	4	8.0*
Work clothes	32	18	56.0	7	22.0	7	22.0
Wife's fibers:							
Man-made	39	33	85.0	5	13.0	1	2.0****
Natural	32	27	84.0	1	3.0	4	13.0**
Husband's fibers:							
Man-made	36	30	83.0	5	14.0	1	3.0****
Natural	32	27	84.0	1	3.0	4	13.0**
Wife's fasteners:[a]							
Buttons	66	59	89.0	1	2.0	6	9.0****
Zippers	70	61	87.0	1	1.5	8	11.5****
Grippers	13	11	85.0	1	7.5	1	7.5*
Wrap and tie	2	2	100.0	0	0.0	0	0.0
Pull-on (elastic)	33	30	91.0	3	9.0	0	0.0****
Husband's fasteners:							
Buttons	67	64	96.0	1	1.0	2	3.0****
Zippers	70	68	97.0	2	3.0	0	0.0****
Grippers	8	8	100.0	0	0.0	0	0.0
Wrap and tie	1	1	100.0	0	0.0	0	0.0
Pull-on (elastic)	9	9	100.0	0	0.0	0	0.0

*.05 level of significance.
**.01 level of significance.
****.0001 level of significance.

[a] Velcro was not used by any of the respondents.

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The Louisiana Agricultural Experiment Station follows a nondiscriminatory policy in programs and employment.

Effects of Various Inoculants on Nitrogen Fixation and Yield of Soybeans*

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One of the most critical problems facing mankind at present is an inadequate supply of protein. This problem has been amplified by the rapidly escalating cost of natural gas, which is an important commodity in the manufacture of commercial nitrogen fertilizers. This has resulted in increasingly expensive fertilizer. It has also contributed to renewed interest in increasing nitrogen fixation by the leguminous plants. These plants are capable of establishing a symbiotic association with root-nodulating bacteria of the genus *Rhizobium.* This association is then capable of using, or "fixing," free nitrogen (N_2) from the air to supply much of the plant's nitrogen needs. Much of the research in this field has been concerned with the soybean-*Rhizobium japonicum* association. This species of *Rhizobium* is usually present in soils that have been previously cropped to soybeans. However, it is sometimes absent from soils that have not been used for soybean production, and therefore this beneficial relationship cannot be established without inoculating the seed just prior to planting.

Research has shown that even when the soybean root system is well nodulated, the amount of N_2 fixed may not be adequate to supply the total needs of the plant. For this reason, introduction of *Rhizobium* strains which are superior N_2-fixers, compared with the indigenous soil strains, appears to be highly desirable. Theoretically, this could be accomplished by inoculation of the seed with these superior strains. However, work in the LSU Department of Agronomy has deomonstrated that it is usually difficult to introduce many of the inoculant-*Rhizobium* into nodules on the roots of soybeans grown in Louisiana soils.

Field research has been conducted for 4 years to determine whether any of the different types of soybean inoculants that are available to Louisiana farmers are capable of increasing N_2 fixation within the soybean plant or of increasing seed yields.

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Experimental Procedure

Test Locations

All tests were conducted at five facilities of the Louisiana Agricultural Experiment Station. These locations, together with some of the properties of the test soils, are listed in Table 1. Tests were conducted only in 1975 at the Ben Hur Farm in Baton Rouge. Data for 2 years were obtained from tests conducted at Idlewild Experiment Station, Clinton, (1975-76), and the Northeast Louisiana Experiment Station, St. Joseph (1977-78). Field tests were conducted at the Burden Research Center, Baton Rouge, and the Red River Valley Experiment Station, Bossier City, for 4 years (1975-78).

Table 1.—Some chemical and physical properties of soils used in testing different soybean inoculants at five locations in Louisiana

Soil properties	Ben Hur Farm	Idlewild Expt. Sta.	Burden Research Center[1]	Red River Valley Expt. Sta.	Northeast Louisiana Expt. Sta.
Soil series	Mhoon	Providence	Olivier	Severn	Commerce
Texture[2]	sicl	sil	sil	fsl	sil
P (ppm)	111	19	53	182	258
K (ppm)	150	142	87	132	203
Ca (ppm)	2,287	490	870	1,135	3,015
Mg (ppm)	441	106	348	284	610
pH	6.0	5.2	5.8	7.3	7.1
Organic matter (%)	1.68	1.90	0.85	0.58	0.77

[1] 300 lb/A of 0-20-20 fertilizer was applied annually.

[2] f = fine; s = sand; si = silt; c = clay; 1 = loam.

Inoculants

All inoculants were obtained from the distributing companies or one of their technical representatives. A new sample was obtained each year an inoculant was used at any of the test locations. Depending on the type of sample, all were stored either in a refrigerator at 4°C or in a freezer at −20°C upon receipt and were taken to test fields packed in ice.

Six different types of inoculants were included in the tests. These included the following forms: peat-base, oil-base, pre-package mixtures, granular formulations, frozen cell-concentrates, and clay-base. Not all inoculants were used at all locations or in all years.

Specific inoculants tested were:

1. Peat-base.—This is the most readily available form of inoculant. It is recommended as a planter-box treatment applied to the seed. All peat

inoculum was provided by the Nitragin Company, Milwaukee, Wisconsin. The peat carrier had a pH of 6.2, a moisture content of 40.5 percent, and contained approximately 10^8 viable rhizobia per gram.

2. Oil-base.—Molynoctin L® and Triple-Noctin L® are oil-based, planter-box treatments sold by Kalo Laboratories, Inc., Kansas City, Missouri. Molynoctin L® is described as a specially formulated liquid suspension of N_2-fixing bacteria and molybdenum (5.34 percent molybdenum). The liquid suspension is purported to isolate the microorganisms from the toxic interactions with the molybdenum. Triple-Noctin L® is quite similar to the Molynoctin L® with a 4.9 percent molybdenum content. It also contains 14.66 percent of the fungicide tetramethylthiuram disulfide (Thiram). Again, this liquid suspension is intended to protect the nodulating bacteria from the toxic effects of both the molybdenum and the fungicide.

3. Pre-packaged mixtures.—Pro-treat 2® and Pro-treat 3® are planter-box treatments sold by the Nitragin Company, Milwaukee. Both consist of two pour-canisters held together by the label. One canister contains 15 ounces of Nitragin's peat-base inoculant. The second canister of the Pro-treat 2® contains 20 ounces of a mixture of 75 percent inert ingredients and 25 percent of the fungicide N-((trichloromethyl) thio)-4 cyclohexene-1,2-dicarboximide (Captan). Pro-treat 3® is identical, except that the second canister also contains 4.75 percent molybdenum. The contents of these two canisters are to be thoroughly mixed immediately before being used to treat 5 bushels of soybean seeds. This reportedly allows for survival of the *Rhizobium,* since they are not in contact with the toxic molybdenum and Captan fungicide until the seeds are ready to be planted.

4. Granular inoculant.—Soil Implant® was provided by the Nitragin Company, Milwaukee. It is a peat-*Rhizobium japonicum* mixture that has been pressed into tiny granules approximately 20 to 60 mesh in size. The mixture is dropped directly into the furrow along with the seed and covered immediately. It is free-flowing and can be metered out uniformly through drill attachments or applicators designed for distribution of small amounts of granular insecticides or herbicides. Little labor is involved. Because it does not depend on its ability to stick to the seed, it can be applied at any rate desired. It normally is applied at about 5 pounds per acre, but there would be no reason why higher rates, and consequently larger numbers of the nodulating bacteria, could not be applied. Chemical seed treatments can be used with less likelihood of killing inoculant bacteria because the granules are applied directly into the soil. Seeds need not be moistened before planting, thereby reducing any danger of seed coat swelling or damage.

5. Frozen concentrates.—These are viscous slurry suspensions of *Rhizobium japonicum* cells that have been concentrated by centrifugation. This allows for extremely high numbers of cells per milliliter. The cells are

kept alive by being maintained in a frozen state. However, the inoculants must be purchased and stored in this frozen state until used. If a culture thaws, it cannot be refrozen without killing many of the cells. On the day the materials are to be used, they are thawed and diluted with water. The volume depends on whether the inoculant is to be used as a direct soil treatment or as a seed treatment. Individual manufacturers' directions must be closely followed at this point, as they vary with the product and use. These inoculants can be applied with pressurized spray systems or gravity flow applicators.

The diluted cell suspensions cannot be mixed with chemicals or fertilizers and cannot be refrozen. The thawed product should be used within 24 hours. High temperatures, such as would be encountered in the summer in Louisiana, are lethal to the nodulating bacteria. If it is necessary to store the unused material during the day it is being used, it should be stored in a refrigerator or ice chest.

The main advantage of the frozen concentrates is that very large numbers of *Rhizobium japonicum* can be placed near the seed in the soil. In our tests, two sources of these frozen concentrates were used: Hy-Rhize,® provided by Microlife Technics of Sarasota, Florida, and Legume-Aid,® provided by Agricultural Laboratories, Inc., Columbus, Ohio.

6. Clay-based inoculants.—These products are manufactured by Agricultural Laboratories, Inc., Columbus, Ohio, and sold under the trade name of Dormal.® At the time of testing, the sample containing added molybdenum was a pre-packaged mixture. This combination is now being marketed in separate containers of molybdenum and inoculant which are mixed just prior to seed application to reduce the possible toxic effects of the molybdenum on the *Rhizobium* cells. Dormal® is a planter-box inoculant and, because of the clay base, it must be applied to dry seed.

Planting

All tests were hand planted using a Planet Jr. or similar type hand planter. All inoculants were applied to the seed or soil at the time of planting. The peat-based, oil-based, pre-packaged mixtures, and the clay-based products were all applied to the seed immediately before planting. The granular inoculant and frozen concentrates were applied directly into the soil at planting. The granular material was applied by removing the hipper and wheel from the hand planter and planting the beans into a furrow that remained opened. The various rates of granular inoculant were then applied into the open seed furrow by hand and the furrow was immediately covered with soil. The frozen concentrates were thawed just before dilution to the test concentrations and applied into the soil with a gravity-flow applicator just behind the seed. The seed and inoculant were immediately covered by the normal action of the planter.

Seed

Bossier cultivar soybean seed was used in all tests at Ben Hur Farm, the Idlewild Experiment Station, and at the Burden Research Center in 1975 and 1976. Dare cultivar seed was used at the Burden Research Center and the Northeast Louisiana Experiment Station in 1977. Centennial cultivar seed was used at these two locations in 1978. This Centennial seed proved to be of poor quality and poor plant stands were obtained. For this reason, no seed yield data were gathered at these two locations in 1978. Bossier cultivar seed was used during all 4 years at the Red River Valley Experiment Station.

Nitrogen Fixation and Seed Yield

When the soybean plants reached the early flowering stage, their roots were carefully excavated from the soil. The acetylene (C_2H_2) to ethylene (C_2H_4) reduction test was run in the field to compare the rate of N_2 fixation between the uninoculated control plants and plants from seed treated with the various inoculants. This field test involved incubating the soybean roots with their attached nodules in sealed glass jars containing 10 percent (v/v) C_2H_2. The metal lids on the jars had been modified with a sealed-in rubber septum to accomodate a syringe needle. At the end of 1 hour, a 10 milliliter sample of gas was withdrawn from each jar and stored in a vacutainer until the concentration of C_2H_4 was determined by gas chromatography in the laboratory. This is a very sensitive test that provides an accurate measurement of how rapidly $N_2(C_2H_2)$ is being fixed by one plant as compared with another. Although a 3:1 ratio appears evident from the following chemical equations, it is desirable to confirm this with an expensive $^{15}N_2$ experiment. When this is not done, results are usually reported as micromoles (μM) of C_2H_4 produced.

The equations are:

A. For N_2 fixation,

$$N_2 + 3H_2 \longrightarrow 2\ NH_3.$$

B. For acetylene (C_2H_2) reduction to ethylene (C_2H_4),

$$HC \equiv CH + H_2 \longrightarrow H_2C = CH_2.$$

After this test, all nodules were removed from the roots, counted, and dry weights were obtained by drying at 60°C for 3 to 4 days.

Seed yield was obtained by cutting the two center rows of plants with a gas-powered Weed-Eater® equipped with a saw blade and then threshing with a small plot thresher. Seed weights were converted to 13 percent moisture and yields (bu/A) were calculated.

All numerical data were subjected to statistical analysis to determine if true differences existed between controls and the various inoculants. Comparisons were made between each individual treatment value and the control value.

Results and Discussion

Three inoculants were tested at the Ben Hur Farm location in 1975 (Table 2). The frozen concentrate (Hy-Rhize®) and the granular (Soil Implant®) inoculants were applied at one- and two-times the manufacturer's recommended rates. There was a highly significant increase in the average number of nodules per plant from the use of the peat-base inoculant. However, well nodulated soybeans can easily exceed 200 nodules per root system. Therefore, even though the value of 16 was significantly higher than the control value, it was still considered to be a very poorly nodulated root system. Seed yields were considered to be quite good. However, none of the inoculant treatments resulted in a statistically significant increase in seed yield.

Table 2.—Effects of various types of inoculants on nodulation and yield of soybeans grown at Ben Hur Farm, Baton Rouge, La., 1975

Inoculant	Rate[1]	No. of nodules per plant	Yield (bu/A)
Control	—	9	35.4
Peat	M	16**	36.0
Hy-Rhize	1	9	33.4
	2	9	36.4
Soil Implant	1	13	34.9
	2	11	35.2

[1] Rate = number times manufacturer's recommended rate; M = massive, or unusually excessive rate.

**Larger than the control value at the 1% level of probability.

Similar testing was conducted at the Idlewild Experiment Station at Clinton in 1975 and 1976 (Table 3). In 1976, a second frozen concentrate (Legume Aid®) was added to the test treatments. Both frozen concentrates, Hy-Rhize® and Legume Aid,® were applied at rates several times in excess of the manufacturer's recommendations in hopes of obtaining a response from heavier applications. In 1976, the nodules were dried and weighed as part of the evaluation procedures. In 1975 and 1976, the use of the peat inoculant resulted in a highly significant increase in the average number of nodules per plant, although nodule numbers were quite low in 1975. In 1976, the average of 122 nodules per plant constituted a substantial increase in nodulation. However, statistical analyses of the dry weight data indicated there were no significant differences between any of the weights. This was interpreted to mean that the higher number of nodules from the peat treatment averaged less weight per nodule and were, therefore, probably smaller nodules. Larger nodules are thought to be the more efficient

Table 3.—Effects of various types of inoculants on nodulation and yield of soybeans grown at Idlewild Experiment Station, Clinton, La., 1975-76

Inoculant	Rate[1]	No. nodules per plant 1975	No. nodules per plant 1976	Dry weight of nodules/plant 1976	Yield 1975	Yield 1976
				(mg)	(bu/A)	(bu/A)
Control	—	11	46	264	22.3	15.2
Peat	M	25**	122**	274	22.4	15.9
Hy-Rhize	1	15	—	—	28.2	—
	2	15	—	—	22.5	—
	5	—	63	241	—	27.2
	25	—	42	130	—	25.3
	50	—	63	238	—	29.8
Legume Aid	5	—	54	165	—	17.4
	25	—	70	195	—	21.5
	50	—	74	232	—	23.0
Soil Implant	1	12	—	—	23.0	—
	2	16	—	—	22.5	—

[1] Rate = number times manufacturer's recommended rate; M = massive, or unusually excessive rate.
**Larger than the control value at the 1% level of probability.

N_2-fixing nodules on soybean roots.[4]

Seed yields were considered low in both years. In 1976, yields from plants inoculated with Hy-Rhize® and those from plants inoculated with Legume-Aid® appeared to be considerably higher than those from plants in the control and peat treatments. However, no statistical differences could be found between the controls and any of the treatments.

A summary of the data obtained in 2 years of testing at the Northeast Louisiana Experiment Station, St. Joseph, is shown in Table 4. Although plants were much better nodulated in 1977 than in 1978, no statistically significant differences were found with respect to average number of nodules or dry weight of nodules in either year. Wide variations in the number of nodules per plant caused average-number-of-nodule values, such as the Pro-treat 3® value, 123, not to be significantly different from the control value of 54. Values in excess of 100 nodules per root would be highly desirable provided the nodules were of sufficient size to be efficient N_2-fixing nodules. The average weight of the nodules on each root system shows that the size of the nodules on the controls was surpassed by only four other treatments. This indicated that nodules on control plants were relatively large in comparison with those from the other treatments. Nodule numbers and nodule dry weight values were considered very low in 1978.

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[4] Alexander, Martin. 1961. Introduction to Soil Microbiology. John Wiley and Sons, Inc. New York.

Table 4.—Effects of various types of inoculants on several parameters of soybeans grown at the Northeast Louisiana Experiment Station, St. Joseph, La. 1977-78[1]

Inoculant	Rate[2]	No. nodules per plant 1977	No. nodules per plant 1978	Dry weight of nodules/plant 1977	Dry weight of nodules/plant 1978	C_2H_4 produced per plant 1977	C_2H_4 produced per plant 1978	Yield 1977
				(mg)	(mg)	(μM)	(μM)	(bu/A)
Control	—	54	13	333	10	2.71	0.24	44.5
Peat	M	104	19	328	39	2.54	1.29	44.1
Molynoctin L	1	92	13	283	15	3.42	0.46	39.5
	5	94	19	434	22	3.52	0.92	40.9
Triple-Noctin L	1	103	9	236	6	3.43	0.10	39.6
	5	97	19	309	27	3.53	1.09	47.0
Pro-treat 3	M	123	13	362	13	3.42	0.58	46.7
Soil Implant	1	61	8	339	6	3.34	0.18	41.1
	5	50	—	274	—	2.82	—	50.8
	10	—	7	—	6	—	0.12	—
Legume Aid	1	56	—	236	—	2.62	—	42.1
	25	103	—	435	—	4.33	—	40.1
	M	—	16	—	25	—	0.62	—
Hy-Rhize	1	93	17	297	18	3.44	0.28	47.8
	10	118	11	307	7	2.26	0.16	40.2

[1] Statistical analyses revealed no significant differences at the 5% level of probability among treatments for any of the parameters measured.

[2] Rate = number times manufacturer's recommended rate; M = massive, or unusually excessive rate.

There were no statistically significant differences between treatments in the average number of micromoles of C_2H_4 produced per plant in either year. Values for the acetylene reduction test reflected the same relationship noted previously for weight of nodules each year; rates of C_2H_4 production were much higher in 1977 than in 1978. This illustrates the value of a well-nodulated soybean root system in N_2 fixation.

Poor-quality seed resulted in poor stands of beans in 1978, and consequently seed yield data were not taken. Seed yields in 1977 were not significantly different between the control and any of the inoculants. However, all yields were considered to be about average for the area and soil type.

The 4 years of data obtained at the Red River Valley Experiment Station at Bossier City are summarized in Table 5. Nine different inoculants were evaluated during this period. No significant differences were found between treatments with respect to average number of nodules per plant in 1975, 1976, or 1978. In 1978, the plants were considered to be very poorly nodulated. In 1977, which was a very dry season at the Red River Station, all rates of every inoculant tested caused highly significant increases in the average number of nodules per plant when they were compared with the control value.

Data on nodule number and dry weight were gathered for 3 years (1976-78). Dry weight data appeared to be closely related to number of nodules each year; i.e., very low values in 1978 and quite high values in 1977. There were statistically significant increases in nodule number per plant due to treatments in 1977, but nodule weight per plant was not significantly different from the control for any of the inoculant treatments, possibly because of the high variation within the treatments. However, it should be noted that the control value was the lowest value found.

The acetylene reduction test was used to check for differences in the rate of N_2 fixation in 1977 and 1978. Although no statistically significant differences were noted in either year, the values again reflected the different degree of nodulation found in the 2 years, with much lower values noted in 1978. Also, in 1977, the lowest value once again was the control value.

Seed yields in 1975, 1976, and 1978 were very good, although not unusually high for the fertile soils of the Red River Valley area. However, no statistically significant difference was found between any of these values when compared with the control values. In 1977, dry summer weather resulted in low yields. Statistical analyses of these low values did reveal significant increases in seed yield from the use of Soil Implant® at the recommended rate and five times the manufacturer's recommended rate and Hy-Rhize® frozen concentrate applied at the recommended rate. It was felt that the strains of *Rhizobium japonicum* contained in these two inoculants might possibly have been better able to survive under dry conditions, but no sound explanation can be given for these significant increases in

Table 5.—Effects of various types of inoculants on several parameters of soybeans grown at the Red River Valley Experiment Station, Bossier City, La., 1975-78

Inoculant	Rate[1]	No. nodules per plant				Dry weight of nodules/plant			C$_2$H$_4$ produced per plant		Yield			
		1975	1976	1977	1978	1976	1977	1978	1977	1978	1975	1976	1977	1978
						(mg)			(μM)		(bu/A)			
Control	—	37	28	76	2	194	288	17	1.90	0.05	56.1	50.9	29.9	52.2
Peat	M	38	24	157**	4	156	772	15	3.82	0.20	51.7	48.1	31.3	54.3
Molynoctin L	1		—	94**	3	—	366	11	3.42	0.04		—	25.0	57.1
	5		—	—	3	—	—	8	—	0.09		—	—	50.5
Triple-Noctin L	1		—	142**	1	—	528	4	4.34	0.03		—	31.3	44.0
	5		—	184**	1	—	375	4	3.10	0.03		—	30.6	43.5
Pro-treat 3	M		—	145**	1	—	590	5	3.28	0.01		—	32.6	56.0
Soil Implant	1	38	40	163**	2	208	413	11	2.77	0.01	53.6	45.1	35.4*	54.9
	2	38	—	—	—	—	—	—	—	—	55.8	—	—	—
	5		47	104**	3	270	297	26	4.99	0.14		48.2	36.1*	50.0
	25		22	—	—	248	—	—	—	—		42.3	—	—
Legume Aid	1		17	105**	—	112	297	—	3.05	—		46.2	31.9	—
	5		8	—	—	48	—	—	—	—		45.3	—	—
	25		19	182**	—	133	390	—	2.78	—		39.1	27.8	—
	50		13	—	—	77	—	—	—	—		51.3	—	—
	M		—	—	4	—	—	30	—	0.32		—	—	56.5
Hy-Rhize	1		20	156**	1	114	419	5	3.58	0.05		46.2	35.4*	48.9
	5		22	—	2	167	—	9	—	0.03		45.9	—	60.3
	10		—	192**	—	—	547	—	4.36	—		—	34.0	—
	25		16	—	—	75	—	—	—	—		49.6	—	—
	50		17	—	—	124	—	—	—	—		50.2	—	—
Dormal	1		21	—	—	112	—	—	—	—		47.5	—	—
Dormal + Mo	1		21	—	—	137	—	—	—	—		45.7	—	—

[1] Rate = number times manufacturer's recommended rate; M = massive, or unusually excessive rate.

* ** = larger than the control value at the 5% or 1% levels of probability.

seed yield.

Data gathered at the Burden Research Center at Baton Rouge during a 4-year period are presented in Table 6. Eleven different inoculants were tested during this period. No statistically significant differences were found for any of the four parameters in any of the years. The summer of 1977 was very dry in this area of the state and this appeared to be reflected in the low nodule number, nodule dry weight, N_2-fixing (C_2H_4 produced) activity, and low seed yield. Poor germination of the Centennial cultivar used in 1978 prevented the accumulation of meaningful data. Those plants which did emerge had a relatively large mass of nodules and high N_2-fixing activity. However, this was probably due to increased availability of photosynthate from the widely spaced plants. No attempt was made to gather seed yield data in 1978.

Table 6.—Effects of various types of inoculants on several parameters of soybeans grown at the Burden Research Center, Baton Rouge, La., 1975-78[1]

Inoculant	Rate[2]	No. nodules per plant 1975	No. nodules per plant 1976	No. nodules per plant 1977	Dry weight of nodules/plant 1976	Dry weight of nodules/plant 1977	Dry weight of nodules/plant 1978	C_2H_4 produced per plant 1976	C_2H_4 produced per plant 1977	C_2H_4 produced per plant 1978	Yield 1975	Yield 1976	Yield 1977
					(mg)			(μM)			(bu/A)		
Control	—	60	55	9	168	15	715	1.62	0.64	26.0	40.9	33.7	26.7
Peat	M	41	60	6	218	21	543	2.73	0.57	18.4	42.6	28.8	29.6
Molýnoctin L	1		—	4	—	14	391	—	0.62	16.3		—	30.2
	5		—	6	—	18	141	—	0.74	6.8		—	27.2
Triple-Noctin L	1		—	11	—	18	587	—	0.90	18.1		—	31.9
	5		—	13	—	21	412	—	0.62	15.4		—	30.1
Pro-treat 2	M		—	—	—	—	422	—	—	13.4		—	—
Pro-treat 3	M		—	10	—	22	228	—	1.07	8.9		—	29.6
Soil Implant	1	37	62	12	236	33	390	3.37	0.89	10.3	40.5	27.8	28.7
	2	43	—	—	—	—	—	—	—	—	46.8	—	—
	5		67	29	263	31	—	2.67	0.92	—		33.9	31.9
	10		—	—	—	—	532	—	—	14.9		—	—
	25		75	—	319	—	—	4.13	—	—		33.3	—
	50		54	—	194	—	—	2.65	—	—		33.3	—
Legume Aid	1		63	13	202	25	—	2.99	0.86	—		33.1	29.9
	5		61	10	224	24	—	2.97	0.85	—		28.2	26.6
	25		85	6	358	27	—	3.59	0.86	—		30.4	26.2
	50		53	3	200	11	—	2.41	0.89	—		28.8	28.3
	M		—	—	—	—	258	—	—	9.9		—	—
Legume Aid RJ586	M		—	—	—	—	438	—	—	9.0		—	—
Legume Aid RJ587	M		—	—	—	—	419	—	—	14.6		—	—
Hy-Rhize	1	37	75	17	328	23	384	1.92	0.47	8.3	46.4	30.1	16.3
	5		83	—	306	—	—	3.72	—	—		27.8	—
	10		—	14	—	15	426	—	0.58	11.5		—	23.7
	25		84	—	327	—	—	3.38	—	—		31.3	—
	50		62	—	298	—	—	3.98	—	—		29.7	—
Dormal	M		—	—	—	—	573	—	—	16.8		—	—

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[1] Statistical analyses revealed no significant differences at the 5% level of probability among treatments for any of the parameters measured.

[2] Rate = number times manufacturer's recommended

Summary and Conclusions

Data on the effects of several different types of soybean inoculants have been gathered during a 4-year period at five different locations in Louisiana. The different inoculants included (1) a peat-base, (2) an oil-base with added molybdenum with or without a fungicide, (3) a clay-base, (4) a granular material, (5) frozen concentrates that were diluted before use, and (6) pre-packaged containers with peat-base inoculant in one container and a fungicide with or without molybdenum in a second container. Effectiveness of the inoculants was assessed by determining the average number of nodules per plant root system, average dry weight of nodules per root system, average micromoles of ethylene produced by the roots with the nodules attached as a measure of the rate of N_2 fixation, and seed yield. Not all parameters were measured at every location in all years. Statistical analyses were conducted to determine if differences existed between the various treatments and the uninoculated control values.

The use of a peat-base inoculant significantly increased the number of nodules per plant at the Ben Hur Farm at Baton Rouge in 1975 and at the Idlewild Experiment Station at Clinton in 1975 and 1976. Neither the peat-base nor any of the other inoculants caused any significant increase in seed yield at either of these locations.

Field experiments were conducted at the Northeast Louisiana Experiment Station, St. Joseph, during the summers of 1977 and 1978. Varying rates of seven different inoculants did not significantly increase the number or dry weight of nodules per plant, or the N_2-fixing ability, in either year, or the seed yield in 1977. Poor seed germination and a poor stand prevented seed yield determinations in 1978.

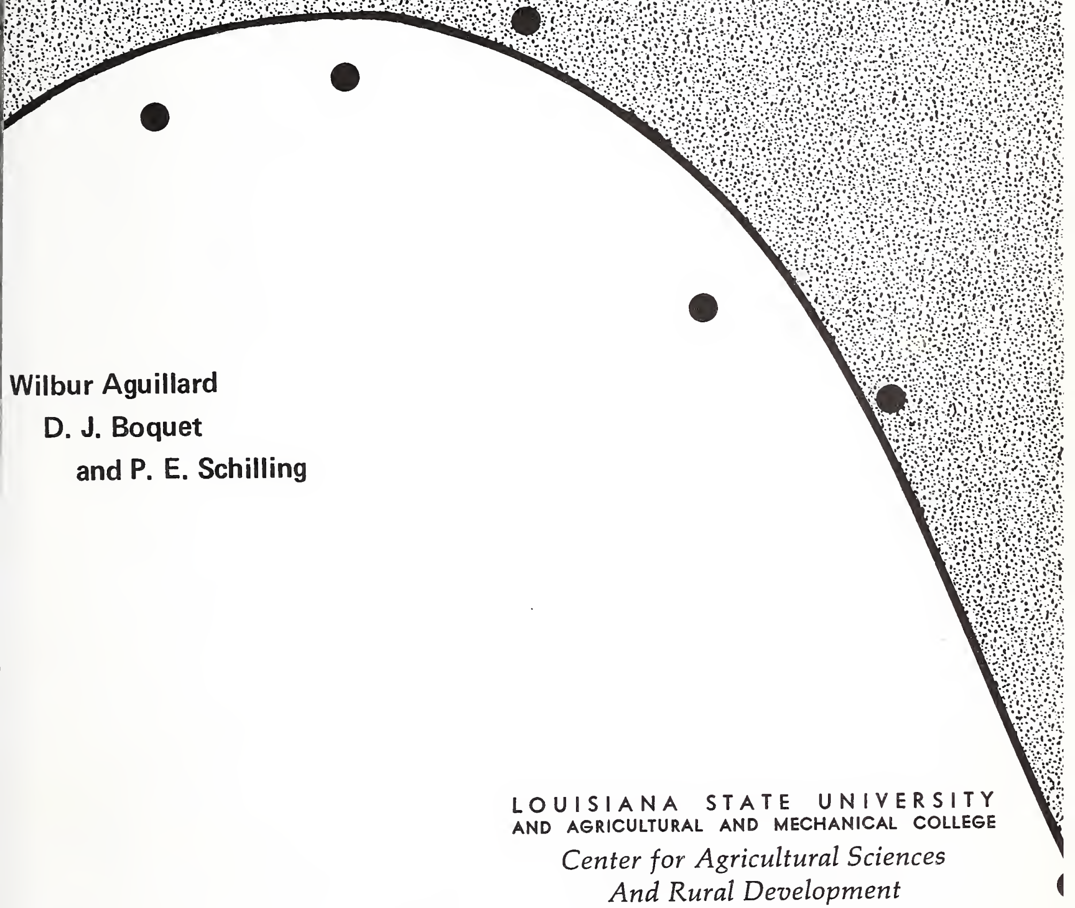
Data were collected at the Red River Valley Experiment Station at Bossier City and the Burden Research Center at Baton Rouge from 1975 through 1978. Nine different types of inoculants were tested during this period at Bossier Cit2y. In 1977, all inoculants tested caused a highly significant increase in number of nodules per plant. No significant differences were found during the other 3 years. No significant differences were noted for nodule dry weight in 1976, 1977, or 1978, nor in N_2-fixing activity, as measured by the acetylene reduction technique, in 1977-78. Good seed yields were obtained in 1975, 1976, and 1978. No significant differences were found between control and treatment values in these years. In 1977, yields were low for this area of the state. Statistically significant increases in seed yield were obtained with the use of the recommended rate and five times the manufacturer's recommended rate of the Soil Implant® granules and from the recommended rate of the liquid inoculant, Hy-Rhize®. Drought conditions prevailed during much of the summer of 1977, and this was partially responsible for the low seed yields.

However, no sound scientific explanation can be advanced for the performance of these two inoculants under these dry conditions.

Eleven different inoculants were tested during the 4-year period at the Burden Research Center. No statistically significant increases were noted from any inoculant in any year with respect to number and dry weight of nodules per plant, N_2-fixing activity, or seed yield. Poor seed germination again prevented seed yield measurements in 1978.

In conclusion, use of commercial soybean inoculants generally did not result in statistically significant increases in nodule number, nodule dry weight, N_2-fixing activity as measured by the acetylene reduction technique, or in seed yield. One exception was in 1977, when use of Soil Implant® and Hy-Rhize® did result in significant increases in seed yield at the Red River Valley Experiment Station when all yields were relatively low because of very dry weather. Generally, the commercial strains of *Rhizobium japonicum* in the carriers tested did not cause any significant responses over that of the native *Rhizobium japonicum* which were already present in the soils at the different test locations.

Effects of Planting Dates and Cultivars on Cotton Yield, Lint Percentage, and Fiber Quality



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Abstract

The effects of eight planting dates on yield, lint percentage, and fiber quality for four cotton cultivars were studied for 5 years at the Northeast Louisiana Experiment Station, St. Joseph, Louisiana. The planting dates were April 1, 10, 20, 30; May 10, 20, 30; and June 10. The cultivars were Deltapine 16, Deltapine 45A, Stoneville 7A, and Stoneville 213. Tests were in a split-plot factorial arrangement with planting dates as main plots and cultivars as subplots in a randomized block design with four replicates.

The analysis of variance technique was used to test for significant differences among means of planting dates and cultivars within dates. Mean squares were tested for significance by use of the F test. Where the F test indicated significant differences, Tukey's method for locating these differences was employed.

Stepwise regression analyses of yield, lint percentage, and quality factors on dates of planting were also conducted as well as correlation analyses between rainfall and temperature and these variables. Also, all possible correlation coefficients were calculated among all variables included in the study.

Results of the April 1 planting date were not included in the analyses and discussion because conditions for planting and seed germination were unfavorable in 3 of the 5 years. Results from another study *(8)*[1] indicated that there was only a 25 percent probability that the temperature required for good seed germination would occur this early.

Highly significant differences occurred among planting dates and cultivars for yield and lint percentage, and for the fiber quality factors fineness, strength, length, uniformity, and elongation. Yield of seed cotton was linearly correlated with planting date and could be predicted reasonably well ($R^2 = 0.29$) with the equation $Y = -1890 + 49.8(x) - .0000072(x)^4$, where x = Julian date. Fluctuations in lint quality with both rainfall and temperature were found to be statistically significant by regression analyses but were judged to be weak to only moderately strong. Correlation coefficients between all yield and lint quality factors showed many highly significant but weak associations of these variables with each other.

Averaged over the 5-year period, interactions between planting dates and cultivars were nonsignificant for yield, lint percentage, and fiber properties. However, there were highly significant interactions in 2 of the 5 years for yield and elongation and in 1 of the 5 years for each of the other variables.

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[1] Italic numbers in parentheses refer to Literature Cited, page 23.

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The Louisiana Agricultural Experiment Station follows a nondiscriminatory policy in programs and employment.

Effects of Planting Dates and Cultivars on Cotton Yield, Lint Percentage, and Fiber Quality

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Introduction

Under proper management, cotton *(Gossypium hirsutum* L.) is one of the most profitable major field crops on a per hectare basis grown in Louisiana. It is also one of the most complex and expensive to produce. The complexity of producing a profitable cotton crop involves many interrelated factors such as cultivar; planting date; fertilization; defoliation; mechanical harvesting; control of weeds, diseases and insects; and ginning for quality preservation. Knowledge of how each of these factors contributes to losses or gains in net income is essential if cotton is to remain a competitive and viable crop.

This study was designed to provide information which could serve as a basis for making decisions on selection of planting dates and cultivars that would result in both optimum yield and quality of cotton fiber. More specifically, the objectives of this experiment were 1) to determine the effect of different dates of planting on yield, lint percentage, and fiber quality, and 2) to evaluate the performance of various cultivars planted on different dates.

Review of Literature

Research by Riley et al. *(8)* on soil temperatures and cotton planting in the mid-south showed that an average temperature of 20°C or higher for 10 days after planting was required for a good rate of seed germination. This minimum temperature is usually realized by April 11 in northeast Louisiana, and the probability of the required temperature occurring earlier is only one in four.

In a 5-year study of the differential effect of planting date on the performance of cotton cultivars on the high plains of Texas, Bilbro and Ray *(3)* concluded that each successive planting made after April 20 generally gave successively lower yields, lint percentages, and fineness values. Fiber length and elongation were also affected by planting dates, and the effect varied with cultivars.

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Hughes *(6)* conducted experiments in Arkansas on effects of planting dates and spacings on cotton. He found that planting date had a significant effect on fiber length but not on strength, fineness, or boll size. Early June plantings produced the longest fibers, May plantings were intermediate, and April plantings produced the shortest fibers.

From a 2-year experiment designed to study the effects of planting date, time of fruiting, and use of insecticides on yield and fiber quality of cotton, Finley, Oliver, and Sloane *(4)* concluded that date of planting materially influenced fiber properties. The study showed that highest levels of quality occurred from mid-May plantings. Differences in strength, length, and elongation between cultivars for each planting date were attributed to the highly significant difference between years in which plantings were made.

McMahon and Low *(7)* used the Growing Degree Day (GDD) concept, which will be explained later, for measuring temperature effects on cotton and concluded that approximately 3,000 GDD were required through the growing season to obtain optimum yields and fiber quality.

Materials and Methods

This experiment was conducted at the Northeast Louisiana Agricultural Experiment Station at St. Joseph from 1968 through 1972. Location of plots differed from year to year, but soil type was consistently a Commerce silt loam in the Order of Inceptisols, Great Group Halaquepts. Growth conditions at the different locations were considered to be similar in effects on yield, gin turnout, and fiber quality. The tests were in a split-plot factorial experimental design with planting dates as main plots and cultivars as subplots. Subplots were four 1 m (40 in.) rows, 20 m (65 ft.) long, replicated four times.

The experiment as originally designed included eight planting dates. However, the first planting date, April 1, was omitted from this discussion since conditions for planting and seed emergence were unsatisfactory in 3 of the 5 years. The approximate planting dates for the experiment were April 10, 20, and 30; May 10, 20, and 30; and June 10. The deviation of the approximate to the actual planting date was no more than 2 days.

Cultivars included in this study differed somewhat from year to year as some were dropped and others added during the course of the study; therefore, cultivars used for analyses and discussion in this paper were limited to those that were common for all 5 years of testing—Deltapine 16, Deltapine 45A, Stoneville 7A, and Stoneville 213.

Cultural practices followed were generally those found to be most conducive to optimum yield production and fiber quality by Louisiana Agricultural Experiment Station research. Fertilization consisted of nitrogen at rates of 78 kg/ha (70 lbs/a) with the exception of 1972 when only 34 kg (30 lbs/a) were needed. All nitrogen was applied preplant and was injected into the bed during the bedding operation as anhydrous ammonia. Preemergence and postemergence herbicides were used in conjunction with mechanical cultivation for weed control. Although the kind and quantity of herbicides varied somewhat from one year to another, this was not believed to affect yields or quality of cotton. Insect numbers were suppressed with a mixture of Toxaphene (chlorinated camphene), DDT (1,1-bis (4-chlorophenyl)-2, 2,2-trichloroethane), and methyl parathion (O,O-dimethyl-o-p-nitrophenyl phosphorothioate) beginning each year when the economic threshold of 25 percent boll weevil damaged squares or 5 percent bollworm damaged squares were found in the field. Cotton for individual dates of planting was defoliated after 65 percent of the bolls were open by applying 1.3 kg/ha (1.1 lbs/a) of DEF (S, S, S, -tributylphosphorotrithioate). Harvesting was accomplished with a two-row mechanical picker that picked the two center rows of the four-row plots.

Plots were harvested, for the most part, in two pickings to determine yield. Time of first picking varied for dates of planting and for years from as early as mid-September to as late as mid-November depending upon the length of the growing season and weather.

Lint percentage and fiber data were determined from a 300 to 800 gram sample of machine-picked seed cotton taken from each plot at first picking. Each sample was ginned on a laboratory model gin and hand cleaned; then the lint and the seed fraction were weighed for lint percentage determination. Lint samples were evaluated by the Louisiana State University Agricultural Experiment Station Cotton Fiber Testing Laboratory for length, length uniformity, fineness, strength, and elongation. All tests were performed in accordance with techniques and procedures set forth by the American Society for Testing and Materials *(1)*.

Since there were several missing samples and replications, the means were adjusted using the least square analysis of variance for unequal number of observations.

Analysis of variance *(9)* was used to test for significant differences among means of planting dates and cultivars within dates for fiber properties, yield, and lint percentage. Where the F test indicated significant differences, Tukey's *(9)* method for locating these differences was employed (average sample size was used). Stepwise regression analyses *(2)* of yield, lint percentage, and quality factors on dates of planting were also conducted.

Since climatic conditions can greatly influence a cotton crop in any given year, correlation analyses were conducted between the climatic factors (rainfall and temperature) and yield, lint percentage, and the five fiber properties included in the study. The correlation analyses included average total rainfall and temperature from the first day of each planting to an arbitrary cut-off of October 31. For temperature, the Growing Degree Day

(GDD) Concept *(7)*, which will be explained in the analyses section, was employed.

Finally, all possible correlation coefficients were calculated among fiber properties, yield, and lint percentage. These correlations were for combined cultivars and planting dates and, therefore, did not separate effects caused by environment and cultivars.

Results and Discussion

Weather Conditions

Table 1 shows the distribution of rainfall by months for the 5 years included in the study. Monthly departures from long-term averages are also indicated.

Total annual precipitation ranged from a low of 119 cm (46.76 in.) in 1969 to a high of 139 cm (55.0 in.) in 1971 with departures from long-term averages of -15 cm (-6.32 in.) and 4 cm (1.5 in.), respectively. Annual

Table 1. — Monthly precipitation and departure from long-term averages, by years and 5-year average, Northeast Louisiana Experiment Station, St. Joseph, Louisiana, 1968-1972

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
	Inches of Rainfall												
1968													
Rainfall	6.48	2.81	3.22	6.33	5.45	1.17	4.02	4.61	1.87	0.36	5.17	8.70	50.19
Departure[1]	1.11	-2.60	-2.76	1.17	0.43	-2.62	-0.68	1.31	-0.53	-1.84	0.79	3.33	-2.89
1969													
Rainfall	1.26	4.20	4.21	6.69	4.86	1.31	5.74	1.51	1.84	4.36	1.66	9.12	46.76
Departure	-4.11	-1.21	-1.77	1.53	-0.16	-2.48	1.04	-1.79	-0.56	2.16	-2.72	3.75	-6.32
1970													
Rainfall	2.41	2.42	4.56	2.64	1.71	3.45	2.95	11.11	3.98	10.44	2.58	3.95	52.02
Departure	-2.96	-3.17	-1.42	-2.52	-3.31	-0.34	-1.75	7.81	1.58	8.24	-1.80	-1.42	-1.06
1971													
Rainfall	2.73	7.77	4.88	2.57	7.91	2.08	2.89	3.32	7.94	1.37	1.65	9.45	54.56
Departure	-2.64	2.36	-1.10	-2.59	2.89	-1.71	-1.81	0.02	5.54	-0.83	-2.73	4.08	1.48
1972													
Rainfall	6.41	2.63	7.35	0.81	3.51	2.01	5.22	2.08	3.95	4.09	3.95	11.33	53.34
Departure	1.04	-2.78	1.37	-4.35	-1.51	-1.78	0.52	-1.22	1.55	1.89	-0.43	5.96	0.26
5-Year Average													
Rainfall	3.86	3.93	4.84	3.81	4.69	2.00	4.16	4.53	3.92	4.12	3.00	8.51	51.37
Departure	-1.51	-1.58	-1.14	-1.35	-0.33	-1.79	-0.54	1.23	1.52	1.92	-1.38	3.14	-1.81

[1] Departure from long-term average rainfall, 1931-1972.

precipitation was slightly below normal in 1968 and 1970 and very near normal in 1972.

To illustrate how rainfall was distributed during the growth period of the cotton plant, rainfall data are presented in Figure 1 for the various planting dates with each period ending on October 31. While total annual rainfall was highest in 1971 and 1972, the amount available during the growth period was considerably higher in 1970, was lowest in 1968, and was about equal for the other 3 years. The monthly precipitation in 1970 was considerably above normal in August and October with record rainfalls of 28 and 36 cm (11.0 and 14.0 in.), respectively.

10.44

As an average of years, a general decline in the amount of rainfall could be noted with each delay in planting starting with a high of 66 cm (26.0 in.) for the April 10 date and ending with a low of 46 cm (18.0 in.) for the June 10 planting (Figure 1). While differences in rainfall were not substantial between any two consecutive plantings, there was a considerable spread between plantings made in April and early May when compared with plantings made in late May and early June. This pattern was notable for each of the 5 years except 1970 when precipitation was remarkably close between planting dates.

Figure 2 illustrates the temperatures which occurred during the period that generally covers plant growth and boll development. Maximum temperatures were almost equal for all 5 years in April, but minimum temperatures fluctuated; however, the average was above 18°C (64°F) which was ample for seed germination. The average temperature increased to well above 21°C (70°F) in May for all years except 1971 which had slightly lower temperatures. The months of June, July, and August had about equal maximum and minimum temperatures for all 5 years. September temperatures varied among years with 1968 and 1969 having the lowest readings. October temperatures dropped considerably from September averages but were fairly uniform for the 5 years.

Yield

The analyses of variance indicated that there were highly significant differences in yield response among planting dates averaged over cultivars for 4 of the 5 years studied and for planting dates averaged over cultivars and years (Table 2). As an average of cultivars and years, yields ranged from a high of 2,582 kg/ha (2,305 lbs/a) of seed cotton for the May 10 date to a low of 1,267 kg/ha (1,131 lbs/a) for the June 10 planting (Table 3). The optimum date for planting appeared to be between April 10 and May 10. Yields produced from an April 10 planting were equivalent to those produced from a May 20 date, and plantings on April 10 and 20 were not significantly different from plantings on May 10 and 20.

In determining whether it would be preferable to plant earlier than April

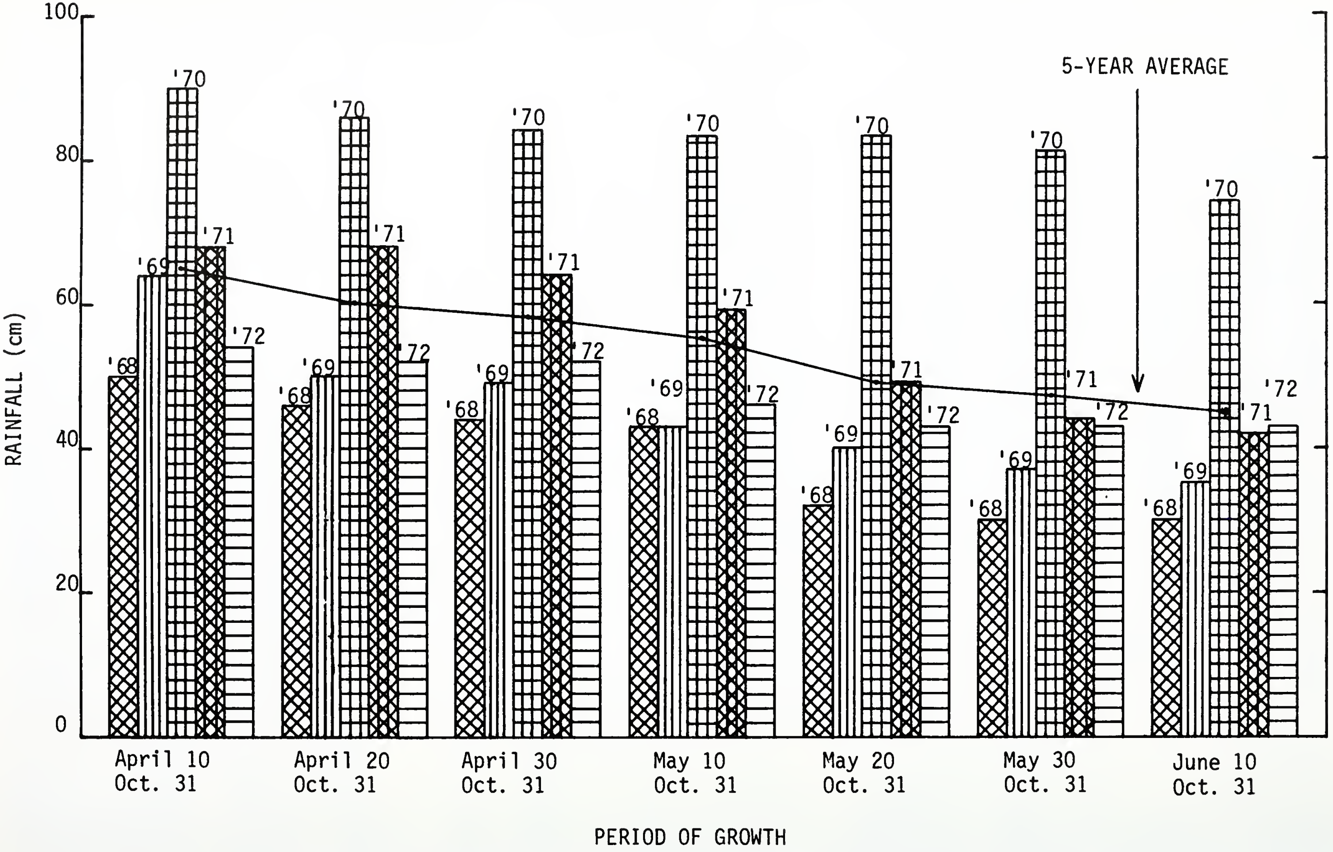

Figure 1.—Amount of rainfall during growing season by years and 5-year average.

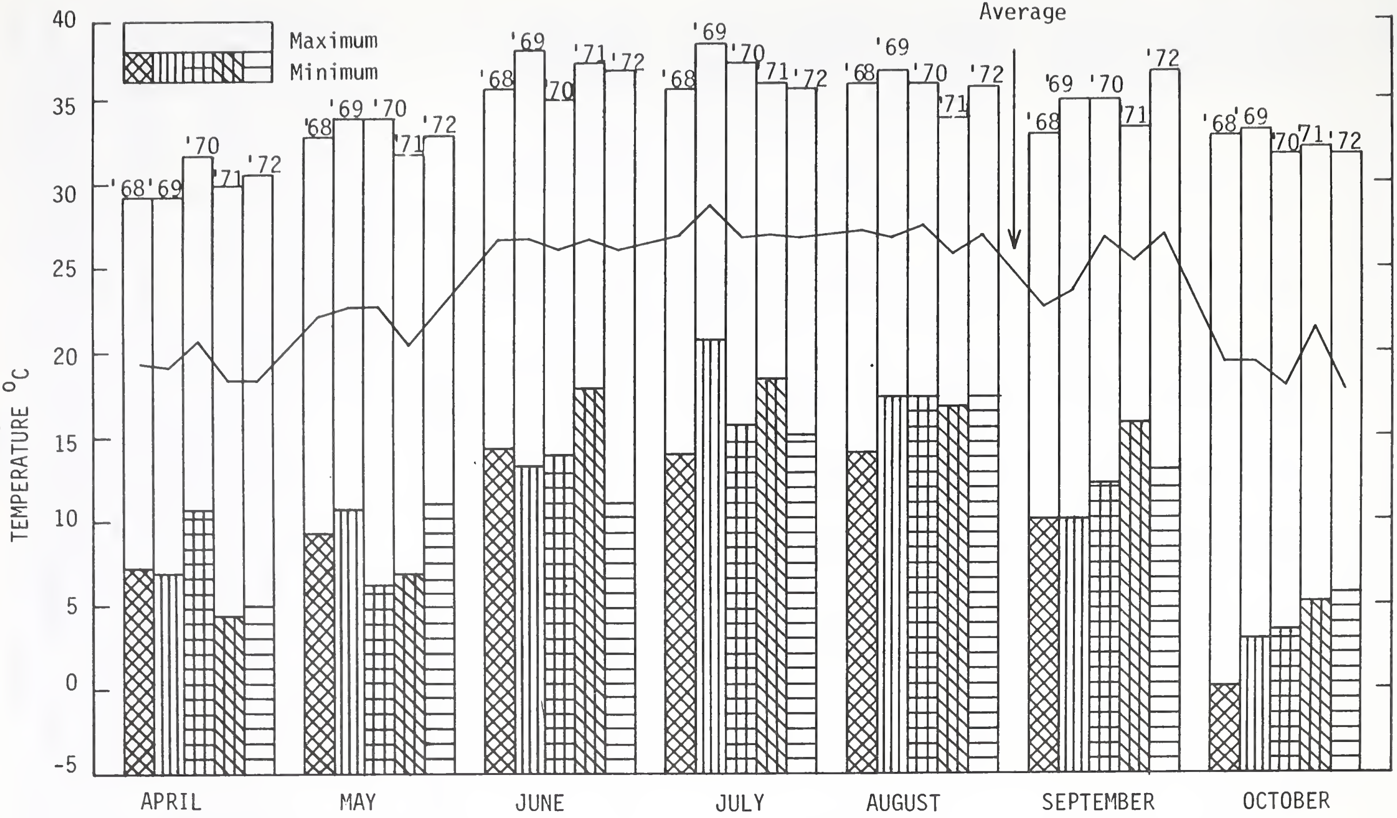

Figure 2.—Maximum, minimum, and average temperatures from April 1 through October 31, by years.

Table 2. — Calculated "F" values for main effects and interaction effects of mean cotton fiber properties, lint percentage, and yield of seed cotton among planting dates and between varieties, by years and 5-year average, 1968-1972

Source of	Fiber Properties					Lint	Pounds of
Variation	Fineness	Strength	Length	Uniformity	Elongation	Percentage	Seed Cotton
1968							
A. Planting Dates	8.20**	17.30**	6.80**	7.90**	3.40**	17.00**	32.80**
B. Varieties	5.10**	3.98*	2.15	17.45**	45.10**	1.18	2.35
A x B	2.09**	0.99	1.18	2.42**	2.71**	1.26	1.66
1969							
A. Planting Dates	23.30**	3.04*	5.60**	12.30**	4.30**	6.10**	2.90
B. Varieties	0.51	21.28**	11.67**	6.68**	81.11**	2.49	1.13
A x B	1.85**	1.95*	1.26	1.17	1.72	1.66	1.32
1970							
A. Planting Dates	2.90**	3.10*	8.30**	0.50	1.10	12.30**	9.70**
B. Varieties	4.46**	3.40*	9.31**	3.78*	42.53**	2.17	4.26**
A x B	1.42	1.39	1.31	0.53	1.38	1.32	0.74
1971							
A. Planting Dates	22.40**	0.50	2.20	1.40	7.10**	2.70	103.10**
B. Varieties	5.88**	1.34	6.89**	1.51	27.92**	3.99*	9.69**
A x B	1.83*	0.99	2.70*	0.65	2.86**	0.69	1.31
1972							
A. Planting Dates	25.20**	1.00	12.50**	8.90**	6.10**	2.00	15.10**
B. Varieties	11.41**	15.81**	14.42**	5.80**	68.10**	0.27	0.72
A x B	1.02	1.61	0.63	0.54	0.67	0.93	0.60
Five-Year Average							
Y. Year	43.93**	19.83**	103.27**	79.77**	73.94**	10.26**	159.85**
A. Planting Dates	23.54**	15.78**	7.70**	2.51*	10.64**	16.60**	88.08**
Y x A	16.09**	7.20**	11.52**	6.18**	2.49**	4.01**	5.70**
B. Varieties	21.24**	18.52**	37.26**	22.58**	29.77**	3.61**	3.45**
Y x B	2.74**	2.78**	1.39	1.37	2.36**	0.86	3.02**
A x B	1.57	0.53	0.76	0.82	1.46	1.04	0.87

*Significant at the .05 percent level of probability.

**Significant at the .01 percent level of probability.

10 or later than May 10 other factors such as the possibility of stand failure for early planting or the probability of increased insect pressure for late-planted cotton should be considered. Farmers having large acreages would also need to consider earlier than optimum plantings in order to avoid excessively late plantings.

Stepwise regression of yield on dates of planting was used to determine the actual closeness of relation between these two variables (Table 4). An R^2 value of .29 was highly significant and indicated 29 percent of the variation in yield was accounted for by variation in planting date. Figure 3 illustrates graphically this association as well as indicating the deviations

Table 3. — Five-year average yield of seed cotton and lint percentage for four cultivars when planted on various dates at the Northeast Louisiana Experiment Station, St. Joseph, Louisiana, 1968-1972

Character & Cultivar	Dates of Planting							Cultivar Average
	April 10	April 20	April 30	May 10	May 20	May 30	June 10	
Yield				*Kilograms of seed cotton/hectare*				
Deltapine 16	2,432	2,454	2,706	2,735	2,285	2,045	1,397	2,288a[1]
Deltapine 45A	2,495	2,485	2,408	2,558	2,099	1,812	1,045	2,115b
Stoneville 7A	2,307	2,396	2,484	2,598	2,135	2,019	1,269	2,167ab
Stoneville 213	2,376	2,532	2,456	2,435	2,074	1,870	1,357	2,141b
Date Average[2]	2,402a	2,466a	2,513a	2,582a	2,148b	1,936c	1,267d	
(HSD.05 between planting dates = 233; between cultivars = 157)								
				Pounds of seed cotton/acre				
Deltapine 16	2,171	2,191	2,416	2,442	2,040	1,826	1,247	2,043
Deltapine 45A	2,228	2,219	2,150	2,284	1,874	1,618	933	1,888
Stoneville 7A	2,060	2,139	2,218	2,320	1,906	1,803	1,133	1,935
Stoneville 213	2,121	2,261	2,193	2,174	1,852	1,670	1,212	1,912
Date average[2]	2,145	2,202	2,244	2,305	1,918	1,729	1,131	
(HSD.05 between planting dates = 208; between cultivars = 140)								
Lint percentage				*Percent*				
Deltapine 16	40.3	40.1	39.8	39.5	39.7	39.5	39.0	39.7b
Deltapine 45A	41.4	41.1	40.5	40.1	39.9	39.3	39.6	40.3a
Stoneville 7A	41.2	40.3	40.8	40.1	40.1	39.2	38.4	40.0ab
Stoneville 213	41.1	40.8	39.5	39.2	39.4	39.0	39.2	39.7ab
Date average[2]	41.0a	40.6ab	40.2bc	39.7cd	39.8cd	39.3d	39.0d	
(HSD.05 between planting dates = .78; between cultivars = .52)								

[1] In the same column for combined planting dates, means followed by the same letter cannot be considered different at the .05 level of probability.

[2] In the same row for combined cultivars, means followed by the same letter cannot be considered different at the .05 level of probability.

Table 4. — Stepwise regression of yield of seed cotton, lint percentage, and cotton fiber properties on planting dates

Property	Equation[1]	R^2
Yield	$-1890 + 49.8\,(\text{day}) - 0.0000072\,(\text{day})^4$	0.29**
Lint percentage	$43.99 - 0.003142\,(\text{day})$	0.11**
Fineness	$7.14 = 0.03604\,(\text{day}) + 0.00011045\,(\text{day})^2$	0.13**
Strength	$18.23 + 0.000000002\,(\text{day})^4$	0.09*
2.5% span length	$2.82 + 0.00000000\,(\text{day})^4$	0.02*
Length uniformity	—	NS
Elongation	$6.82 + 0.0091945\,(\text{day})$	0.03*

[1] Yield, strength, and 2.5% span length expressed in metric system. Julian days used are: April 10 = 100; April 20 = 110; April 30 = 120; May 10 = 130; May 20 = 140; May 30 = 150; June 10 = 161.

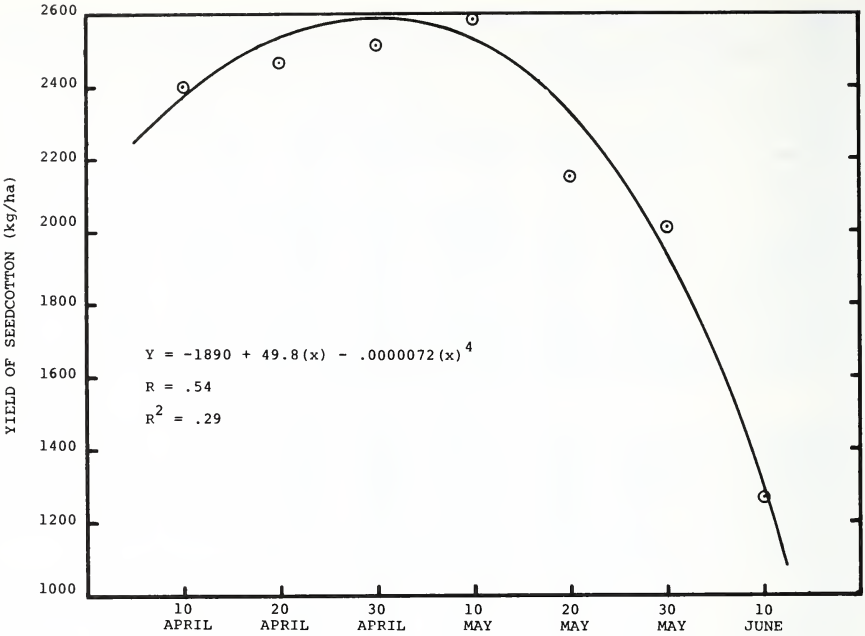

Figure 3.—Relationship between dates of planting and yield of cotton, 5-year average.

between actual and predicted yields derived from the regression equation $Y = -1890 + 49.8(x) - .0000072(x)^4$.

Differences in yield response among cultivars were not significant for 3 of the 5 years studied. However, differences were highly significant both in 1970 and 1971 and as an average of years (Table 2).

The data in Table 3 show that Deltapine 16 significantly outyielded Deltapine 45A at all but the first two planting dates and was especially superior to Deltapine 45A at the June 10 date. Furthermore, Deltapine 16 significantly exceeded the yield of Stoneville 213 at each of the four middle planting dates (April 30 thru May 30) and significantly outyielded Stoneville 7A at two of the seven dates (April 30 and May 20). However, the analyses of variance did not indicate any interaction between cultivars and dates of planting for any of the 5 years nor as an average of years (Table 2). This seems to suggest that there was no substantial differential response of cultivars over dates of planting.

These data indicate that proper cultivar selection could be an important managerial decision. The importance of cultivar selection increases when planting is unavoidably delayed beyond May 30 because it could affect final yield of seed cotton per hectare by as much as 25 percent. Note that the yield of the lowest yielding cultivar expressed as a percentage of the highest yielding was 92, 96, 89, 91, 91, 89, and 75 for April 10, April 20, April 30, May 10, May 20, May 30, and June 10 planting dates, respectively. Varietal trials that are designed to provide information on the performance of cultivars are usually planted on or near the optimum dates of April 20 to May 10, and information on the performance of specific cultivars on any other dates of planting is therefore not generally available.

Lint Percentage

There were highly significant differences in lint percentage among planting dates for 3 of the 5 years and as an average of years (Table 2). Lint percentage values were generally highest for the first planting date (April 10) and declined with each delay in planting, reaching their lowest value on the June 10 date (Table 3). The significant reduction in lint percentage with delay in planting means that the optimum planting date based on yield of lint would be slightly earlier than that indicated on the basis of yield of seed cotton.

The analysis showed no significant interactions between cultivars and planting dates (Table 2), indicating that the four cultivars behaved alike with respect to lint percentage. Averaged over the 5-year period, Deltapine 45A had the highest lint percentage followed by Stoneville 7A with Deltapine 16 and Stoneville 213 being about the same. Variations among cultivars over planting dates and years were small, but varietal response was consistent within dates of planting. When values for combined dates were averaged, the range of difference between cultivars was a low but highly significant 0.6 percent.

Cotton Fiber Properties

Other studies have shown the existence of variations in cotton fiber properties due to differences between cultivars and environmental growth conditions. The genetic constitution of a cultivar determines the upper and lower limit of quality that the fiber may attain, but environmental growth conditions are the cause of fluctuations within this range. This section describes differences among dates of planting and cultivars for each of the five cotton fiber properties included in the analyses: fineness, strength, elongation, length, and length uniformity.

Regression equations (see Table 4) relating each of the five fiber properties to planting dates were derived from stepwise regression analyses. The coefficients of determination (R^2) obtained from the regression equations were significant at the 1 percent level of probability for strength, length, and elongation, and the 5 percent level of probability for fineness, while length uniformity had no significant relationship with planting dates (Table 4). Although the R^2 values were significant for all but length uniformity, the closeness of relationship between each of the other fiber properties with planting dates was moderate to weak. Because of the weak relationships, estimated values from the stepwise regression were plotted only for fiber fineness (Figure 4). Except for fineness, the proportion of variance of the five other fiber properties explained by planting dates was considered too low to be meaningful. Further research is needed to ascertain what other factor or factors were responsible for differences that were apparent from one planting date to another.

There were highly significant differences in fiber fineness among planting dates for each of the 5 years of the study and for the combined period. Differences between cultivars were highly significant for 4 of the 5 years and also as an average of the 5-year period (Table 2).

Although there was a measurable relation in which fineness values changed with dates of planting, the actual decrease in fineness with delay in planting was moderate, ranging from 4.7 at the earliest date to 4.2 at the latest date (Table 5). Since the magnitude of the variation in fineness over the range of dates was rather small, the relationship of fineness to dates would have had to be extremely consistent in order to be strongly associated. This was not the case, however, especially for later planting dates which showed wide variations in fineness within dates. For example, for the June 10 date, fineness readings ranged from an average of 3.9 in 1971 to 5.0 in 1972. The inconsistency in fineness for very late planted cotton can be explained by the greater variability in growing conditions experienced by late plantings, especially length and quality of the growing season as governed by air temperature. Such differences in growing conditions would have resulted in differences in degree of maturity of first pick cotton from which samples were taken for quality determinations.

The regression equation for predicting fineness of cotton fiber for any given date of planting is given in the scatter diagram of Figure 4. Note that although a definite relationship exists between fineness and dates, only 13 percent of the variation in fineness can be accounted for by differences in dates.

From the standpoint of cultivars, the combined 5-year period shows that the two Stoneville cultivars produced the coarsest cotton and were equal in this respect. The two Deltapine cultivars were similar to each other in fineness but were 0.2 micronaire units below Stoneville 7A and Stoneville 213 (Table 5).

The analyses indicated that cotton fiber fineness values trended downward with each delay in planting, as was the case with lint percentages. This was expected since there was a highly significant positive correlation between these two variables (Table 6).

Reduction in fineness and lint percentage values with each delay in planting may be attributed to the fact that as the dates of planting were later,

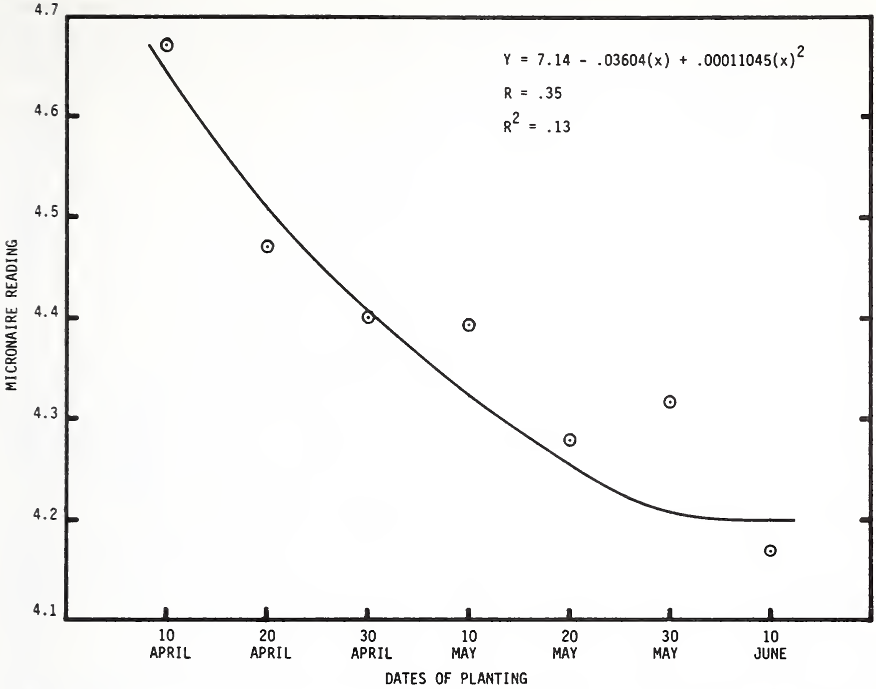

Figure 4.—Relationship between dates of planting and fineness of cotton fibers, 5-year average.

the growing season became shorter and the air temperature became lower, shortening the effective boll maturation period to the extent that many fibers did not mature before defoliation or the first frost in the fall. While there were some immature fibers for all planting dates, the degree of immaturity increased with late plantings.

When averaged over the 5-year period, the analyses of variance showed that there were highly significant differences in cotton fiber strength among planting dates. Within years, however, differences among dates were highly significant in 1968, were significant in 1969 and 1970, and not significant in 1971 and 1972 (Table 2).

For the 5-year period, strength values tended to increase slightly with each delay in planting, reaching their highest value on the June 10 date. As an average of cultivars, the range of difference was from 18.5 to 19.6 grams/tex (Table 5).

Highly significant differences occurred among cultivars in 1969 and 1972 and as an average of years. Significant differences occurred in 1968 and 1970 but not in 1971 (Table 2). The two Deltapine cultivars had remarkably similar strength values when compared with each other.

Table 5. — Five-year average cotton fiber properties for four cultivars when planted on various dates at the Northeast Experiment Station, St. Joseph, Louisiana, 1968-1972

Character & Cultivar	Dates of Planting							Cultivar Average
	April 10	April 20	April 30	May 10	May 20	May 30	June 10	
Fineness				*Micronaire Reading*				
Deltapine 16	4.54	4.42	4.34	4.20	4.15	4.24	4.16	4.28b[1]
Deltapine 45A	4.61	4.33	4.23	4.46	4.10	4.14	4.09	4.27b
Stoneville 7A	4.79	4.53	4.51	4.45	4.35	4.44	4.22	4.46a
Stoneville 213	4.72	4.61	4.52	4.45	4.51	4.47	4.20	4.49a
Date Average[2]	4.67a	4.47b	4.40bc	4.39bc	4.28cd	4.32c	4.17d	
(HSD .05 between planting dates= .13; between cultivars= .09)								
Strength				*Grams/tex*				
Deltapine 16	18.6	18.9	19.0	19.3	19.3	19.3	20.0	19.2a
Deltapine 45A	19.1	18.5	18.9	19.0	19.3	19.6	19.6	19.2a
Stoneville 7A	18.0	18.1	18.3	18.4	18.5	18.7	19.3	18.5b
Stoneville 213	18.2	18.3	18.3	18.5	18.7	18.8	19.5	18.6b
Date Average[2]	18.6d	18.5d	18.6cd	18.8bcd	19.0bc	19.1b	19.6a	
(HSD .05 between planting dates= .45; between cultivars= .30)								
Length				*Percent*				
Deltapine 16	1.13	1.12	1.14	1.13	1.14	1.12	1.14	1.13a
Deltapine 45A	1.10	1.10	1.10	1.08	1.10	1.09	1.12	1.10b
Stoneville 7A	1.12	1.11	1.13	1.12	1.13	1.12	1.15	1.13a
Stoneville 213	1.11	1.11	1.11	1.11	1.11	1.11	1.13	1.11b
Date Average[2]	1.11b	1.11b	1.12b	1.11b	1.12b	1.11b	1.13a	
(HSD .05 between planting dates= .009; between cultivars= .013)								
Uniformity				*Percent*				
Deltapine 16	45.50	45.19	46.10	45.50	45.15	45.85	46.05	45.63a
Deltapine 45A	46.33	46.88	46.80	46.05	46.30	46.45	46.90	46.52b
Stoneville 7A	45.39	44.47	45.00	44.60	45.25	45.30	45.60	45.10c
Stoneville 213	45.83	45.67	45.70	45.40	46.05	46.45	45.95	45.87b
Date Average[2]	45.76ab	45.53ab	45.90ab	45.39b	45.69ab	46.01ab	46.13a	
(HSD .05 between planting dates= .68; between cultivars= .45)								
Elongation				*Percent*				
Deltapine 16	8.2	8.9	9.0	8.6	9.4	9.4	9.0	8.9a
Deltapine 45A	7.9	8.5	8.5	8.1	8.4	8.8	8.6	8.4b
Stoneville 7A	6.8	6.8	6.8	6.9	7.0	7.2	7.2	7.0c
Stoneville 213	7.5	7.7	7.7	7.6	7.7	8.0	7.9	7.7d
Date Average[2]	7.6c	8.0ab	8.0ab	7.8bc	8.1ab	8.3a	8.2a	
(HSD .05 between planting dates= .30; between cultivars= .20)								

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[1] In the same column for combined planting dates, means followed by the same letter cannot be considered different at the .05 level of probability.

[2] In the same row for combined cultivars, means followed by the same letter cannot be considered different at the .05 level of probability.

Likewise, the two Stoneville cultivars were almost equal to each other in strength. However, examination of the 5-year average strength data revealed that the two Deltapine cultivars were consistently stronger with a

Table 6. — Correlation coefficients among cotton fiber properties, yield of seed cotton per hectare, and lint percentage for four combined cultivars when planted on various dates at the Northeast Louisiana Experiment Station, St. Joseph, 1968-1972

Variable[1]	Variable[1]					
	V_3	V_4	V_5	V_6	V_7	V_8
V_1	0.15**	0.20**	0.06	-0.25**	-0.05	0.26**
V_3		-0.13**	-0.46**	0.06	0.22**	-0.09*
V_4			0.20**	0.13**	-0.01	-0.04
V_5				-1.18**	-0.35**	0.16**
V_6					0.20**	-0.34**
V_7						-0.07
V_8						

V_1[1] = Yield of seed cotton per hectare.
V_3 = 2.5% span length.
V_4 = Length uniformity.
V_5 = Fineness.
V_6 = Strength.
V_7 = Elongation.
V_8 = Lint percentage.
*Significant at the .05 level.
**Significant at the .01 level.

significant strength advantage over the Stoneville cultivars for all planting dates.

The 5-year average values for cotton fiber elongation showed highly significant differences among planting dates and cultivars (Table 2). Fiber elongation for combined cultivars ranged from a low of 7.6 percent for the April 10 planting to a high of 8.3 percent for the May 30 date. All four cultivars showed a general increase in elongation as planting dates were delayed (Table 5).

For combined planting dates, differences in cultivars ranged from a low elongation value of 7.0 percent to a high of 8.9 percent for Stoneville 7A and Deltapine 16, respectively. Deltapine 45A had the second highest elongation (8.4 percent) followed by Stoneville 213 (7.7 percent). Each cultivar was significantly different from the others. This order of difference in elongation was noted for each planting date (Table 5). Differences between cultivars were highly significant for all 5 years (Table 2).

The 2.5 percent span length showed highly significant differences among planting dates for the combined 5-year period and for each year except 1971. Differences in cultivars were highly significant for all years except 1968 (Table 2). When comparing differences among planting dates for combined cultivars, the data showed a narrow 2.5 percent span length range of 28 to 29 mm (1.11 to 1.13 in.), a difference of only 0.4 mm (0.15 in.) (Table 5). This difference in range also applied to each of the four cultivars. Consequently, planting dates did not seem to have a substantial influence on the 2.5 percent span length.

Differences among cultivars did exist. Deltapine 16 and Stoneville 7A produced the longest fibers, while Deltapine 45A and Stoneville 213 fibers were shorter and about equal in length. Since there were no interactions involving cultivars, differences among cultivars were independent of planting dates and must be attributed to their genetic makeup. Although there were highly significant differences among cultivars, it should be pointed out that the length values for each of the four cultivars were highly acceptable.

Differences in length uniformity were highly significant among planting dates as an average of years and for 3 of the 5 years (Table 2). Length uniformity was unaffected by planting dates in 1970 and 1971. As an average of cultivars, comparisons among planting dates revealed that length uniformity values were very similar for the first five plantings (April 10 through May 20) and showed a moderate increase for the May 30 and June 10 dates.

All four cultivars responded about the same with changes in planting dates. However, Deltapine 45A had consistently higher length uniformity values for all planting dates followed by Stoneville 213, Deltapine 16, and Stoneville 7A (Table 5). Differences among cultivars as an average of dates and years varied from a high of 46.52 percent for Deltapine 45A to a low of 45.10 percent for Stoneville 7A, a difference in range of 1.50 percent.

Although highly significant differences were found among cultivars, length uniformity for each of the four cultivars was considered acceptable with a rating of average to high. This also applied to differences among planting dates.

Correlation Analyses

For a given cultivar, differences in yield, lint percentage, and fiber properties are due to environmental growth conditions. This includes soil types, cultural practices, and climate. Rainfall and temperature are probably the most important elements of climatic conditions. Consequently, when cultivars, soil types, and cultural practices are constant, variations in yield, lint percentage, and fiber properties are mainly due to variation in rainfall and temperature. In order to determine how closely associated these variables were with rainfall and temperature, correlation analyses were used.

Table 7 shows the correlation coefficients between the seven variables (yield, lint percentage, and five fiber properties) and rainfall and temperature.

The temperature data are presented in modified form using the Growing Degree Day Concept. This concept was used in this experiment to study temperature relationships with yield, lint percentage, and fiber properties.

Table 7. — Correlation coefficients (R) between yield, lint percentage, and fiber properties of specified cultivars, and rainfall and Growing Degree Days at the Northeast Louisiana Experiment Station, St. Joseph, 1968-1972

	Rainfall+				Growing Degree Days++			
Fiber Property	Deltapine 16	Deltapine 45A	Stoneville 7A	Stoneville 213	Deltapine 16	Deltapine 45A	Stoneville 7A	Stoneville 213
2.5% span length	-0.15	-0.12	-0.17	-0.10	-0.15	-0.22	-0.27	-0.31
Length uniformity	-0.12	-0.22	-0.21	-0.28	-0.09	0.15	-0.24	-0.08
Fineness	0.13	0.23	0.19	0.11	0.44*	0.42*	0.47*	0.49**
Strength	-0.33*	-0.41*	-0.12	-0.33*	-0.25	-0.14	-0.42	-0.37
Elongation	-0.23	-0.12	-0.12	-0.12	-0.29	-0.26	-0.47*	-0.28
Lint percentage	0.38*	0.49*	0.40*	0.38*	0.19	0.37*	0.47*	0.45*
Yield	0.30	0.36*	0.11	0.17	0.38*	0.49**	0.43*	0.51**

+ Five-year average, 1968-1972.
++ Four-year average, 1969-1972.
*Significant at the .05 level.
**Significant at the .01 level.

It was accomplished by the accumulation of daily mean temperatures above a specified threshold. In this study, growing degree days were accumulated using 16°C (61°F) as the threshold temperature. The following calculations were made for each day with a cumulative total of growing degree days resulting for the entire season:

$$GDD = \frac{T_{max} + T_{min}}{2} - T_{th}$$

GDD = Growing Degree Days

T_{max} = Maximum temperature

T_{min} = Minimum temperature

T_{th} = Threshold temperature

Correlation analyses showed that both fineness and yield had significantly positive associations with GDD, indicating that growing seasons having the largest number of GDD resulted in coarser fiber and higher yields of seed cotton. A significant positive association occurred between GDD and lint percentage for all cultivars except Deltapine 16. Reasons for Deltapine 16 responding differently to GDD in regard to this characteristic cannot be determined from available data. Examination of data revealed that lower strength and elongation values were associated with seasons having the highest GDD and that as GDD diminished these values increased. Statistical analyses, however, showed that strength and elongation were negatively correlated with GDD only for Stoneville 7A, and even this relationship was not especially strong.

Rainfall was correlated with strength for three of the cultivars and with yield of Deltapine 45A. At best, the strength of these associations, although significant, could be termed weak to only moderately strong. Rainfall and lint percentage correlation coefficients were positive and moderately strong as rainfall accounted for 14 to 24 percent of the variation in lint percentages, depending upon cultivar.

Individually, neither GDD nor rainfall seemed to be of special importance in their effect upon cotton quality and yield, because most correlation coefficients were either nonsignificant or not strong enough to be meaningful. For those factors having significant associations with either GDD or rainfall, indications were that the influence of GDD was more important than rainfall. The data strongly suggest, however, that during the years this study was conducted, and for the planting dates used, GDD and rainfall were present in sufficient or excess quantities so that these climatic variables imposed almost no limitations on the yield and quality of cotton. It would seem that the progressive decline in yield for cotton planted after May 10 was due to factors that were not evaluated in this experiment. Perhaps a knowledge of the amount of precipitation and GDD during various phases of plant and fruit development would be more meaningful in the interpretation of climatic effects on cotton than was the total occurrence during the growing season.

All possible correlation coefficients were determined between cotton fiber properties, yield, and lint percentage. Highly significant correlations occurred between many of the variables, but, as presented in Table 6, R values were generally low.

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An Economic Comparison Of Intensive Beef Cow-Calf Programs With Cotton and Soybeans

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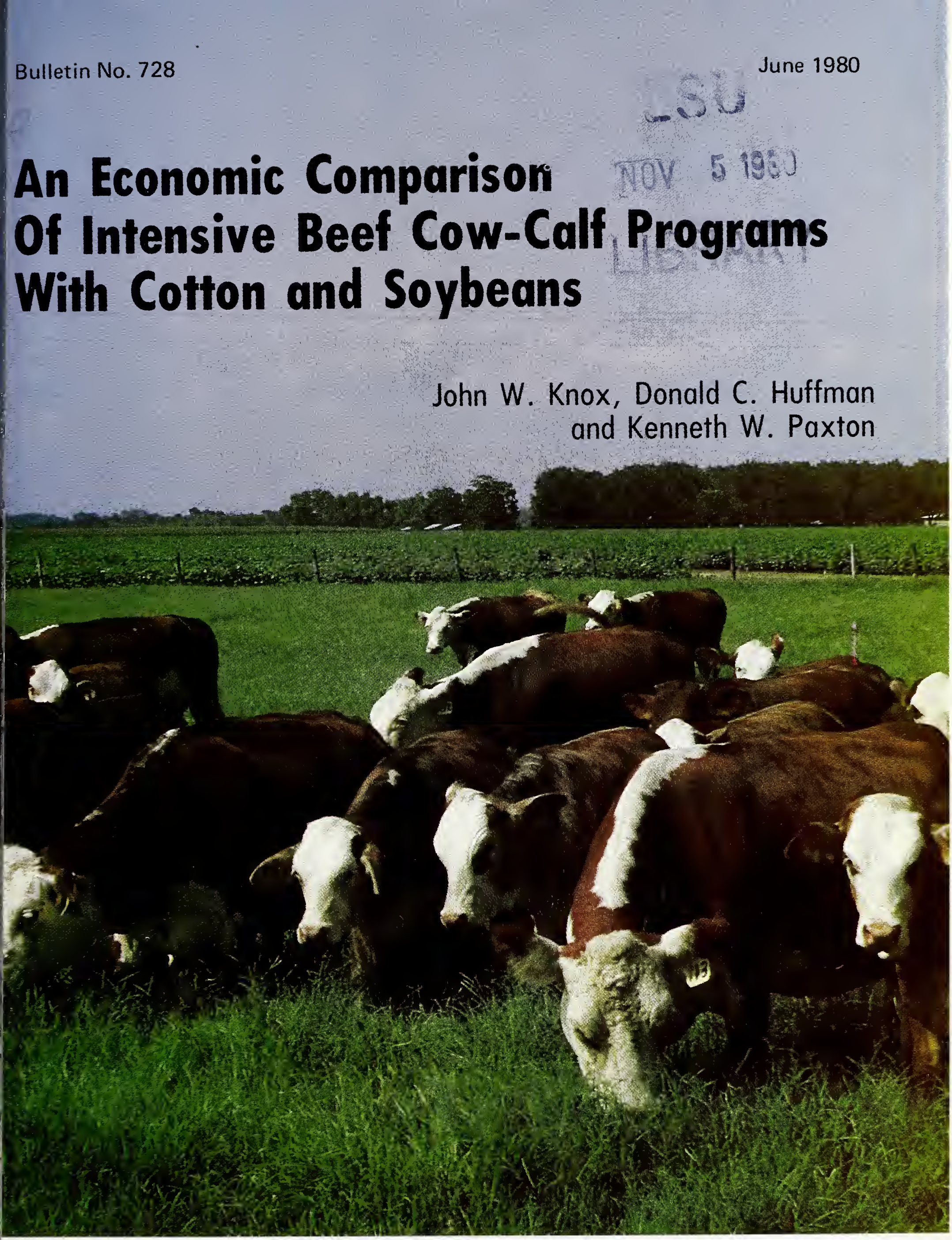

LOUISIANA STATE UNIVERSITY
AND AGRICULTURAL AND MECHANICAL COLLEGE
Center for Agricultural Sciences
And Rural Development

AGRICULTURAL EXPERIMENT STATION

Preface

This report compares three intensive cow-calf programs with cotton and soybeans. Data used in the report were taken from experiments conducted during a 15-year period at the Red River Valley Experiment Station, Bossier City. Experimental regimes were conducted consecutively rather than simultaneously. Therefore, comparisons must be made with due consideration for differences in productivity among periods as well as confounding of year effects with breed effects resulting from crossbreeding in the third time period. Since this report is based on experimental data, levels of outputs shown here should not be compared directly with actual farm records. The comparisons shown are believed to be valid since data for all enterprises were obtained from experiments conducted under similar conditions at the same location. Therefore, while the absolute level of performance might vary between the experiment and an actual farm, the relationships among enterprises should remain relatively constant.

The stability of these relationships is examined in the report by comparing the enterprises at various price levels. As price levels increase, the cow-calf programs become more competitive with the row-crop enterprises. Based on 1979 price and cost relationships, the creep-graze system with F_1 calves gave the highest returns of the cow-calf systems considered. Returns per acre from this system were slightly higher than returns from soybeans but were lower than those from cotton. However, labor requirements per acre were considerably higher for all cow-calf systems than for cotton or soybeans.

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The Louisiana Agricultural Experiment Station follows a nondiscriminatory policy in programs and employment.

An Economic Comparison of Intensive Beef Cow-Calf Programs With Cotton and Soybeans

JOHN W. KNOX,[1] DONALD C. HUFFMAN[2] AND
KENNETH W. PAXTON[2]

This study compares the economic potential of three beef cow-calf programs with cotton and soybean enterprises. Data for the comparison were obtained from experiments conducted during the period 1962-76 at the Red River Valley Experiment Station, Bossier City, La., on alluvial soils. All physical input-output data used were taken from experiment station records and may or may not reflect levels of production attainable by farmers. The objective of this analysis was to determine if intensive cow-calf programs could compete economically with traditional row crops for available resources in agricultural production.

Pasture Program

The general pasture program for the beef cattle experiment was begun in 1955. A 16-acre Coastal bermudagrass pasture was established and cross-fenced into two pastures of equal size. Each fall the pastures were overseeded with Louisiana S-1 white clover and ryegrass. A total of 250 pounds of nitrogen was applied in split applications to the pastures in early spring, midsummer, and late summer. Accumulated manure was spread three times per year. Pastures were clipped and surplus forage was harvested as hay. Pastures were alternately grazed and harvested to provide continuous grazing for the cattle. Coastal bermudagrass was allowed to grow as much as possible in the late fall for stubble grazing. Hay harvest was possible in all but one year, 1969. During 1969, excess hay from previous years was used for winter feeding.

Cow-Calf Program

The basic cow-calf program involved 24 cows and 24 calves on the 16 acres of pasture. This general stocking rate was maintained throughout the experiment. This program was designed to evaluate beef production per acre from pastures stocked at a given level rather than to evaluate breeding performance. Brood cows were bred during a 75-day breeding season to calve between September 15 and December 1. Calves were weaned in mid-July at about 9 months of age. All calves were vaccinated for blackleg, and brood cows were vaccinated annually for vibriosis and leptospirosis. In addition, brood cows received an injection of vitamin A prior to the breeding season. Cows were wormed twice in the fall and twice in the spring to control internal parasites. External parasites were controlled by spraying or dusting four times per year. Total medication cost was estimated to be $9.50 per head at 1979 prices.

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Hereford brood cows were used in the cow-calf program throughout the 15-year period (1962-76). However, three different management programs were followed within the 15-year period. During the first 5-year period (1962-66), cows were bred to Hereford bulls and the calves received no supplemental feeding of any kind. Hereford bulls were also used during the second 5-year period (1967-71), and the calves received an average of 587 pounds of supplemental grain. During the third 5-year period (1972-76), Hereford brood cows were bred to several different breeds of bulls to produce crossbred calves and the calves were permitted to creep graze an additional 4 acres of ryegrass from December 1 through July 15. The animals were fed hay harvested from the pastures. During the first two 5-year periods, slightly more hay was required than was harvested from the pastures, while surplus hay was harvested during the third time period. After adjusting for the additional land required to produce hay and the land used for creep grazing, the effective stocking rates were .74 acre per cow for the first 5-year period, .69 acre per cow for the second period, and .83 acre per cow for the last 5-year period when creep grazing for the crossbred calves was included. This program involved an additional 4 acres for creep grazing (December-July). Additional hay could have been harvested from these acres, and credit for an additional 2 tons per acre for the 4 acres was included in this system. Since the experimental regimes were conducted consecutively rather than simultaneously, comparisons must be made with due consideration for differences in productivity among periods as well as the confounding of year effects with breed effects resulting from crossbreeding in the third time period.

Cotton and Soybean Production

Data from experiments on the station served as a basis for the cotton and soybean production programs used in the comparison. Six-row equipment was assumed for both cotton and soybean production. The cotton production program involved deep tillage after stalk destruction, followed by a disking. Cotton land was set up in rows during the fall or winter with an allowance for re-hipping part of the acreage before planting. Sixty pounds of nitrogen from anhydrous ammonia was applied in the spring. Weed control practices consisted of an application of a preemergence herbicide, two applications of a postemergence herbicide, and three mechanical cultivations. Insect control consisted of 12 applications of a synthetic pyrethroid material. Cotton was chemically defoliated and was mechanically harvested twice during the season. A charge for ginning was included in the cotton budgets.

Land preparation for soybean production consisted of disking two times, followed by a rowing-up operation. A bed conditioner was used just before planting. A preemergence herbicide was applied at planting and two mechanical cultivations were performed during the growing season. Two applications of a fungicide were utilized in soybean production. No insecticides were used.

Comparison of Enterprises

For purposes of this analysis, the beef cattle programs were treated as three distinct programs as noted previously. Technical input-output relationships discovered in the experiments were used in conjunction with estimated 1979 prices to develop costs and returns for the various beef programs. Although all three programs did not exist simultaneously in the experiments, this analysis provides comparisons of costs and returns for all systems in 1979 as well as in each of the 5-year periods. Historical experimental yield data for 1962-76 were used to establish the level of output for cotton and soybeans. Technology has changed over time, and therefore current (1979) technical inputs were used in conjunction with estimated 1979 prices to develop budgets for cotton and soybeans. The per-acre production for each of the enterprises is shown in Table 1. Comparisons shown in this report are based on experimental data and do not reflect actual farming situations. The results should not be compared directly with actual farm records.

A comparison of estimated 1979 costs and returns per acre for each enterprise is shown in Table 2. Cotton yielded the highest net return per acre of the enterprises considered ($251.48). The program utilizing F_1 calves with creep grazing was the most profitable beef program per acre and net returns from this program ($183.82) were slightly greater than those from soybeans ($182.35 per acre). This beef program had a less intensive stocking rate than the other systems (.83 acre per cow *vs.* .74 and .69 acre per cow). The beef program including creep feeding of grain yielded the largest output per acre (683 pounds), but did not yield the highest profit. Extra feed costs incurred for grain caused this program to have higher variable costs than the other feeding programs. Detailed budgets and supporting data for all enterprises in this comparison are shown in Appendix Tables 1-7.

Table 1.—Average yields per acre for beef cattle, cotton, and soybeans, Red River Valley Experiment Station, 1962-76[1]

	Beef systems				
Year	No Creep feeding	Creep feed grain	F_1 calves, creep graze	Cotton (lint)	Soybeans
	-----------------------	Lb./A.	-----------------------	Lb./A.	Bu./A.
1962	544			635	30.2
1963	520			667	42.1
1964	538			731	30.4
1965	544			621	40.0
1966	527			627	47.7
(5-year avg.)	(534)			(656)	(38.1)
1967		707		660	49.4
1968		653		509	47.4
1969		661		1,060	20.2
1970		688		1,164	29.7
1971		705		1,076	38.3
(5-year avg.)		(683)		(894)	(37.0)
1972			625	1,323	44.5
1973			589	970	60.4
1974			563	733	52.4
1975			573	1,215	56.3
1976			624	1,071	42.6
(5-year avg.)			(595)	(1,062)	(51.2)
Overall avg.				871	42.1

[1] Five-year averages may not equal those shown in budgets due to rounding.

The impact that different price levels would have on the economic relationships among these enterprises is shown in Table 3. Data in this table were based on the same levels of production and costs outlined above; the only change was in the product prices. Beef cattle become less competitive with cotton and soybeans as the product price level drops. The reverse relationship holds when product prices rise. For all levels of prices evaluated, the program involving F_1 calves with creep grazing was most competitive with the row-crop enterprises. If cattle prices were to rise by 10 percent and soybean prices were to remain at the base level, the program with F_1 calves and creep grazing would yield net returns per acre superior to soybeans. Data presented in Table 3 provide similar comparisons for additional relationships. These data may also be interpreted as changes in output as well as changes in price, or a combination of both.

Net return per acre is perhaps the single most important consideration in enterprise selection, but labor requirements are also very important. Annual labor requirements per acre for the enterprises considered are shown in Table 4. Labor requirements per acre for the three beef cattle programs range from 166 to 181 percent of those for cotton. Soybeans require about

Table 2.—Comparison of estimated costs and returns per acre for selected beef enterprises, cotton, and soybeans, Red River Valley Experiment Station, 1979

Item	Beef systems				
	No creep feeding	Creep feed grain	F_1 calves, creep graze	Cotton	Soybeans
	Dollars				
Gross returns	347.84[1]	443.70[2]	417.20[3]	603.60[4]	260.40[5]
Variable costs	173.22	224.61	132.42	283.59	57.96
Fixed costs	109.14	114.78	100.96	68.53	20.09
Total specified costs	282.36	339.39	233.38	352.12	78.05
Net returns to land and management	65.48	104.31	183.82	251.48	182.35

[1] Production for this system is 3.96 cwt./cow and .74 acre/cow. Gross returns = 3.96/.74 x $65 = $347.84.

[2] Production for this system is 4.71 cwt./cow and .69 acre/cow. Gross returns = 4.71/.69 x $65 = $443.73.

[3] Production for this system is 4.96 cwt./cow and .83 acre/cow, plus .57 ton of hay per acre. Gross returns = (4.96/.83 x $65) + (.57 x $50) = $417.20.

[4] Production is 871 pounds of lint and 1,350 pounds of seed per acre. Gross returns = (871 x $.60) + (1,350 x $.06) = $603.60.

[5] Production is 42 bushels/acre. Gross returns = 42 x $6.20 = $260.40.

3.65 hours of labor per acre, or about 45 percent of the labor requirement for cotton. Total labor per cow is relatively constant among livestock systems, with the least intensive system (creep grazing) having the lowest labor requirement per acre.

Estimated costs and returns for each enterprise based on price relationships for the three time periods described earlier are shown in Tables 5-7. These tables were based on average production for each row crop enterprise for the 15-year period 1962-76. Input costs were indexed back to each time period from the 1979 base using the index of farm production expenses. Returns were based on the average level of production for 1962-76 and the average prices during each of the respective 5-year time periods. Production for each of the livestock programs was held constant for all time periods. Net returns for the various beef programs changed as a result of absolute price changes; relationships among the feeding programs did not change. Creep grazing with F_1 calves was most competitive with row-crop enterprises in all periods. During the 1967-71 time period, this feeding program yielded net returns greater than those from cotton and soybeans. Cotton lint prices were extremely depressed during this time (24 cents per pound) and soybean prices were about $2.65 per bushel. The price relationships among commodities were substantially different in each of the time periods included in the analysis.

Table 3.—Net returns per acre to land and management for selected beef cattle systems, cotton, and soybeans at selected price levels, Red River Valley Experiment Station, 1979[1]

		Net returns - beef systems			Cotton		Soybeans	
Price level	Beef price ($/cwt.)	No creep feeding ($)	Creep feed grain ($)	F_1 calves, creep graze ($)	Price ($/lb. lint)	Net returns[2] ($)	Price ($/bu)	Net returns ($)
–20 percent	52.00	–4.09	15.57	105.08	.48	146.96	4.96	130.27
–10 percent	58.50	30.70	59.94	144.95	.54	199.22	5.58	156.31
Base	65.00	65.47	104.31	183.82	.60	251.48	6.20	182.35
+10 percent	71.50	100.26	148.68	222.69	.66	303.74	6.82	208.39
+20 percent	78.00	135.05	193.05	261.56	.72	356.00	7.44	234.43

[1] Assumes the following levels of production: no creep feeding—3.96 cwt./cow and .74 acre/cow; creep feed grain—4.71 cwt./cow and .69 acre/cow; creep graze—4.96 cwt./cow and .83 acre/cow, plus .57 ton of surplus hay per acre; cotton—871 pounds of lint and 1,350 pounds of seed per acre; soybeans—42 bushels per acre.

[2] Price for cotton seed held constant at $120 per ton for all lint price levels.

Table 4.—Annual labor requirements for selected beef cattle systems, cotton, and soybeans, Red River Valley Experiment Station, 1979

	Beef cattle				
Enterprise	Livestock labor	Pasture labor	Hay labor	Total labor	Annual labor requirement per acre[1]
	Hours/cow				Hours
Beef systems					
No creep	6.8	1.23	2.87	10.90	14.73
Creep grain	6.8	1.28	2.20	10.23	14.83
F_1 calves, creep graze	6.8	1.38	3.13	11.31	13.63
Cotton					8.19
Soybeans					3.65

[1] Per-acre labor requirements based on .74 acre/cow for no creep feeding, .69 acre/cow for creep grain, and .83 acre/cow for creep grazing. Hours per acre for no creep feeding = 10.9/.74 = 14.73; hours/acre for creep grain = 10.23/.69 = 14.83; hours/acre for creep grazing = 11.31/.83 = 13.63.

Table 5.—Estimated costs and returns per acre for selected beef systems, cotton, and soybeans, Red River Valley Experiment Station, 1962-66

	Beef systems				
Item	No creep feeding	Creep feed grain	F_1 calves, creep graze	Cotton	Soybeans
	Dollars				
Gross returns[1]	142.67[2]	181.98[3]	172.67[4]	287.69[5]	104.58[6]
Variable costs[7]	73.72	95.59	56.36	120.70	24.67
Fixed costs[7]	46.45	48.85	42.97	29.17	8.55
Total specified costs[7]	120.17	144.44	99.33	149.87	33.33
Net returns to land and management	22.50	37.54	73.34	137.82	71.36

[1] Gross returns based on average prices received for the 5-year period. Livestock prices were the average price of all calves at Louisiana auction markets for the 5-year period plus $3 per hundredweight to account for the higher quality animals in the experimental program.

[2] Production for this system is 3.96 cwt./cow and .74 acre/cow. Gross returns = 3.96/.74 x $26.66 = $142.67.

[3] Production for this system is 4.71 cwt./cow and .69 acre/cow. Gross returns = 4.71/.69 x $26.66 = $181.98.

[4] Production for this system is $4.96 cwt./cow and .83 acre/cow, plus .57 ton of hay/acre. Gross returns = (4.96/.83 x $26.66) + (.57 x $23.22) = $172.67.

[5] Production is 871 pounds of lint and 1,350 pounds of seed per acre. Gross returns = (871 x $.29) + (1,350 x $.026) = $287.69.

[6] Production is 42 bushels per acre. Gross returns = 42 x $2.49 = $104.58.

[7] Input cost data are 1979 estimates indexed back to the appropriate time period using the index of farm production expenses. The index number for 1962-66 is 93.2, with 1967 = 100 and 1978 = 219.

Table 6.—Estimated costs and returns per acre for selected beef systems, cotton, and soybeans, Red River Valley Experiment Station, 1967-71

Item	Beef systems			Cotton	Soybeans
	No creep feeding	Creep feed grain	F1 calves, creep graze		
	Dollars				
Gross returns[1]	172.15[2]	219.60[3]	206.20[4]	245.49[5]	111.30[6]
Variable costs[7]	85.10	110.35	65.06	139.33	28.48
Fixed costs[7]	53.62	56.39	49.60	33.67	9.87
Total specified costs[7]	138.72	166.74	114.66	173.00	38.35
Net returns to land and management	33.43	52.86	91.54	72.12	72.95

[1] Gross returns based on average prices received for the 5-year period. Livestock prices were the average prices of all calves at Louisiana auction markets for the 5-year period plus $3 per hundredweight to account for the higher quality animals in the experimental program.

[2] Production for this system is 3.96 cwt./cow and .74 acre/cow. Gross returns = 3.96/.74 x 32.17 = $172.15.

[3] Production for this system is 4.71 cwt./cow and .69 acre/cow. Gross returns = 4.71/.69 x 32.17 = $219.60.

[4] Production for this system is 4.96 cwt./cow and .83 acre/cow, plus .57 ton of hay/acre. Gross returns = (4.96/.83 x $32.17) + (.57 x $24.24) = $206.20.

[5] Production is 871 pounds of lint and 1,350 pounds of seed per acre. Gross returns = (871 x $.24) + (1,350 x $.027) = $245.49.

[6] Production is 42 bushels per acre. Gross returns = 42 x $2.65 = $111.30.

[7] Input cost data are 1979 estimates indexed back to the appropriate time period using the index of farm production expenses. The index number for 1967-71 is 107.6, with 1967 = 100 and 1978 = 219.

Table 7.—Estimated costs and returns per acre for selected beef systems, cotton, and soybeans, Red River Valley Experiment Station, 1972-76

Item	Beef systems				
	No creep feeding	Creep feed grain	F_1 calves, creep graze	Cotton	Soybeans
	Dollars				
Gross returns[1]	212.40[2]	270.93[3]	259.78[4]	450.96[5]	230.16[6]
Variable costs[7]	130.83	169.65	100.02	214.20	43.78
Fixed costs[7]	82.43	86.69	76.26	51.76	15.17
Total specified costs[7]	213.26	256.34	176.28	265.96	58.95
Net returns to land and management	−.86	14.59	83.50	185.00	171.21

[1] Gross returns based on average prices received for the 5-year period. Livestock prices were the average prices of all calves at Louisiana auction markets for the 5-year period plus $3 per hundredweight to account for the higher quality animals in the experimental program.

[2] Production for this system is 3.96 cwt./cow and .74 acre/cow. Gross returns = 3.96/.74 x $39.69 = $212.40.

[3] Production for this system is 4.71 cwt./cow and .69 acre/cow. Gross returns = 4.71/.69 x $39.69 = $270.93.

[4] Production for this system is 4.96 cwt./cow and .83 acre/cow, plus .57 ton of hay/acre. Gross returns = (4.96/.83 x $39.69) + (.57 x $39.35) = $259.78.

[5] Production is 871 pounds of lint and 1,350 pounds of seed per acre. Gross returns = (871 x $.448) + (1,350 x $.045) = $450.96.

[6] Production is 42 bushels per acre. Gross returns = 42 x $5.48 = $230.16.

[7] Input cost data are 1979 estimates indexed back to the appropriate time period using the index of farm production expenses. The index number for 1972-76 is 165.4, with 1967 = 100 and 1978 = 219.

Summary and Implications

Based on data presented in this analysis, the cow-calf program utilizing F_1 calves and creep grazing generated net returns about equal to those from soybeans, but less than those from cotton. These results were based on experimental yields and current (1979) cost-price relationships. If relative prices change in favor of beef cattle, they could generate profits superior to soybeans or cotton, depending upon the extent of the change. Although comparisons of the beef cattle programs must be made with caution, it appears that the program utilizing crossbred calves and creep grazing has the greatest economic potential. This program was slightly less intensive than the others (.83 acre per cow *vs*. .74 and .69 acre per cow) and utilized less labor per acre. However, labor requirements for both row-crop enterprises were considerably lower than those for the creep grazing program. Labor availability for an individual farmer may be a critical factor that provides a relative advantage for the soybean enterprise, which is the least labor intensive (3.65 hours per acre).

Average production among the 5-year periods was relatively stable for all enterprises. Year-to-year variations did exist, which could alter the relationships shown in Table 3. For example, a 10 percent increase in output of the creep grazing program would make net returns from that program superior to net returns from soybeans. Historically, changes in prices have been of a larger magnitude than changes in production. Therefore, changes in product prices will play a dominant role in deciding the profitability of the enterprises considered in this report.

Appendix Table 1.—Estimated 1979 costs per head for a cow-calf operation (no creep feeding), Red River Valley Experiment Station, 1962-66[1]

Item	Unit	Price or cost/unit (dollars)	Quantity	Value or cost (dollars)
Variable costs				
Pasture (sodseed)	tons	75.08	0.67	50.30
Stock salt	cwt.	3.50	0.50	1.75
Bone meal	cwt.	18.50	0.50	9.25
Medication	head	9.50	1.00	9.50
Hay (pasture)	tons	13.86	1.13	15.66
Hay (produced)	tons	21.98	0.36	7.91
Tractors (fuel, lube, repairs)	dol.			0.81
Machinery (fuel, lube, repairs)	dol.			4.09
Equipment (fuel, lube, repairs)	dol.			3.26
Labor, tractor & machinery	hrs.	3.27	2.40	7.85
Labor, livestock	hrs.	3.27	4.40	14.39
Interest on operating capital	dol.	0.10	40.42	4.04
Total variable costs				128.18
Fixed costs				
Pasture (sodseed)	acre	7.61	0.67	5.10
Hay (pasture)	tons	6.34	1.13	7.16
Hay (produced)	tons	6.92	0.36	2.49
Interest on livestock capital	dol.	0.10	492.00	49.20
Interest on other equipment	dol.	0.10	49.88	4.99
Depreciation on other equipment	dol.			7.84
Other fixed costs, mach. & equip.	dol.			3.98
Total fixed costs				80.76
Total specified costs per head				208.94
Total specified costs per cwt.				52.76

[1] Average weight of weanling calves was 3.96 cwt.

Appendix Table 2.—Estimated 1979 costs per head for a cow-calf operation (creep grain), Red River Valley Experiment Station, 1967-71[1]

Item	Unit	Price or cost/unit (dollars)	Quantity	Value or cost (dollars)
Variable costs				
Pasture (sodseed)	tons	75.08	0.67	50.30
Stock salt	cwt.	3.50	0.50	1.75
Bone meal	cwt.	18.50	0.50	9.25
Medication	head	9.50	1.00	9.50
Hay (pasture)	tons	13.86	1.05	14.55
Hay (produced)	tons	21.98	0.09	1.98
Grain creep feed	cwt.	5.66	5.87	33.22
Tractors (fuel, lube, repairs)	dol.			0.18
Machinery (fuel, lube, repairs)	dol.			4.09
Equipment (fuel, lube, repairs)	dol.			3.52
Labor, tractor & machinery	hrs.	3.27	2.40	7.85
Labor, livestock	hrs.	3.27	4.40	14.39
Interest on operating capital	dol.	0.10	43.93	4.39
Total variable costs				154.98
Fixed costs				
Pasture (sodseed)	acre	7.61	0.67	5.10
Hay (pasture)	tons	6.34	1.05	6.66
Hay (produced)	tons	6.92	0.09	0.62
Interest on livestock capital	dol.	0.10	492.00	49.20
Interest on other equipment	dol.	0.10	52.54	5.25
Depreciation on other equipment	dol.			8.37
Other fixed costs, mach. & equip.	dol.			4.00
Total fixed costs				79.20
Total specified costs per head				234.18
Total specified costs per cwt.				49.72

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[1] Average weight of weanling calves was 4.71 cwt.

Appendix Table 3.—Estimated 1979 costs per head for a cow-calf operation (creep graze), Red River Valley Experiment Station, 1972-76[1]

Item	Unit	Price or cost/unit (dollars)	Quantity	Value or cost (dollars)
Gross receipts				
Hay (excess)	tons	50.00	0.47	23.50
Total				23.50
Variable costs				
Pasture (sodseed)	tons	75.08	0.67	50.30
Stock salt	cwt.	3.50	0.50	1.75
Bone meal	cwt.	18.50	0.50	9.25
Medication	head	9.50	1.00	9.50
Hay (pasture)	tons	13.86	1.62	22.45
Creep grazing	acre	33.02	0.17	5.61
Tractors (fuel, lube, repairs)	dol.			0.18
Machinery (fuel, lube, repairs)	dol.			4.09
Equipment (fuel, lube, repairs)	dol.			3.75
Labor, tractor & machinery	hrs.	3.27	2.40	7.85
Labor, livestock	hrs.	3.27	4.40	14.39
Interest on operating capital	dol.	0.10	42.89	4.29
Total variable costs				133.41
Net variable costs				109.91
Fixed costs				
Pasture (sodseed)	acre	7.61	0.67	5.10
Hay (pasture)	tons	6.34	1.62	10.27
Creep grazing	acre	3.09	0.17	0.53
Interest on livestock capital	dol.	0.10	492.00	49.20
Interest on other equipment	dol.	0.10	56.72	5.67
Depreciation on other equipment	dol.			8.99
Other fixed costs, mach. & equip.	dol.			4.04
Total fixed costs				83.80
Total specified costs per head				217.21
Net specified costs per head				193.71
Net specified costs per cwt.				39.05

[1] Average weight of weanling calves was 4.96 cwt.

Appendix Table 4.—Estimated 1979 costs per acre for soybeans, Red River Valley Experiment Station, 1962-76

Item	Unit	Price or cost/unit (dollars)	Quantity	Value or cost (dollars)
Gross receipts				
Soybeans	bu.	6.20	42.00	260.40
Total				260.40
Variable costs				
Pre-harvest costs				
Soybean seed	bu.	12.00	1.00	12.00
Preemergence herbicide	qt.	3.54	0.80	2.83
Fungicide	lbs.	7.50	1.00	7.50
Airplane (lo vol)	acre	1.90	2.00	3.80
Machinery (fuel, lube, repairs)	acre	2.27	1.00	2.27
Tractors (fuel, lube, repairs)	acre	8.56	1.00	8.56
Labor (tractor & machinery)	hrs.	3.27	2.52	8.25
Other labor	hrs.	3.27	0.45	1.47
Interest on operating capital	dol.	0.10	19.63	1.96
Subtotal, pre-harvest				48.65
Harvest costs				
Machinery	acre	7.09	1.00	7.09
Labor (tractor & machinery)	hrs.	3.27	0.68	2.21
Subtotal, harvest				9.31
Total variable costs				57.96
Income above variable costs				202.44
Fixed costs				
Machinery	acre	13.03	1.00	13.03
Tractors	acre	7.06	1.00	7.06
Total fixed costs				20.09
Total specified costs				78.05
Net returns to land and management				182.35

Appendix Table 5.—Estimated 1979 costs per acre for cotton, Red River Valley Experiment Station, 1962-76

Item	Unit	Price or cost/unit (dollars)	Quantity	Value or cost (dollars)
Gross receipts				
Cotton lint	lbs.	0.60	871.00	522.60
Cotton seed	lbs.	0.06	1,350.00	81.00
Total				603.60
Variable costs				
Pre-harvest costs				
Preemergence herbicide	lbs.	2.75	0.50	1.38
Nitrogen 82	cwt.	9.00	0.60	5.40
Cotton seed	cwt.	28.00	0.20	5.60
Postemergence herbicide	lbs.	2.05	0.75	1.54
Lay-by herbicide	lbs.	3.27	1.00	3.27
Insecticide	qt.	52.48	1.50	78.72
Airplane (lo vol)	acre	1.90	12.00	22.80
Defoliant	gal.	12.50	0.25	3.13
Airplane (hi vol)	acre	2.40	1.00	2.40
Insect scout	acre	4.00	1.00	4.00
Machinery (fuel, lube, repairs)	acre	3.08	1.00	3.08
Tractors (fuel, lube, repairs)	acre	14.61	1.00	14.61
Labor (tractor & machinery)	hrs.	3.27	3.35	10.96
Other labor	hrs.	3.27	1.64	5.36
Interest on operating capital	dol.	0.10	55.39	5.54
Subtotal, pre-harvest				167.79
Harvest costs				
Ginning	lbs.	0.07	871.00	60.97
Machinery	acre	35.56	1.00	35.56
Labor (tractor & machinery)	hrs.	3.27	3.20	10.46
Subtotal, harvest				106.99
Total variable costs				274.78
Income above variable costs				328.82
Fixed costs				
Machinery	acre	55.99	1.00	55.99
Tractors	acre	12.53	1.00	12.53
Total fixed costs				68.53
Total specified costs				343.30
Net returns to land and management				260.29

Appendix Table 6.—Machinery and equipment fixed and variable costs per hour, Louisiana, 1979

		Variable costs per hour				Fixed costs per hour				
Machine	Code[1]	Repairs	Fuel	Lubricants[2]	Total variable	Depreciation	Insurance	Total fixed	Interest cost per hour	Total ownership and operating cost per hour[3]
		Dollars								
Tractor, 31-55 HP	2	1.051	0.888	0.133	2.071	0.631	0.068	0.699	0.756	3.526
Tractor, 56-80 HP	3	1.420	1.404	0.211	3.034	1.024	0.110	1.134	1.226	5.394
Tractor, 106-130 HP	5	2.065	2.786	0.418	5.268	1.984	0.214	2.198	2.376	9.843
Pickup truck	10	0.460	1.434	0.215	2.109	1.105	0.053	1.159	0.590	3.858
5-Ton truck	12	0.963	2.868	0.430	4.262	2.188	0.147	2.334	2.334	6.662
Combine, medium	14	17.317	3.055	0.458	20.830	15.410	1.061	16.471	11.791	49.092
Cotton picker, 2R	16	21.054	3.302	0.495	24.851	19.984	1.376	21.361	15.291	61.503
Cotton picker, 2R	17	21.054	3.302	0.495	24.851	19.984	1.376	21.361	15.291	61.503
Disk, 6R	32	2.818	0.0	0.0	2.818	2.549	0.171	2.720	1.898	7.436
Hipper, 6R	38	1.093	0.0	0.0	1.093	0.989	0.066	1.055	0.736	2.884
Chisel plow	45	0.679	0.0	0.0	0.679	0.615	0.041	0.656	0.458	1.793
Cultivator, 6R	48	1.279	0.0	0.0	1.279	1.157	0.078	1.235	0.861	3.375
Cult-post, 6R	51	1.759	0.0	0.0	1.750	1.591	0.107	1.698	1.185	4.642
Planter-pre, 6R	57	2.520	0.0	0.0	2.520	2.603	0.174	2.778	1.938	7.236
Stalk shredder 2	60	0.373	0.0	0.0	0.373	0.675	0.045	0.720	0.503	1.596
Spike harrow, 4R	62	0.200	0.0	0.0	0.200	0.181	0.012	0.193	0.135	0.528
Conditioner, 6R	65	1.399	0.0	0.0	1.399	1.266	0.085	1.350	0.942	3.691
Trailer, utility	67	0.213	0.0	0.0	0.213	0.214	0.018	0.232	0.199	0.644
Cotton trailer	68	0.500	0.0	0.0	0.500	0.476	0.035	0.511	0.389	1.400
Mower-conditioner	71	6.739	0.0	0.0	6.739	2.709	0.182	2.891	2.017	11.701
Hayrake	72	1.016	0.0	0.0	1.016	0.736	0.049	0.785	0.548	2.349
Hayfork	73	0.077	0.0	0.0	0.077	0.070	0.005	0.075	0.052	0.204
Grain drill	74	1.049	0.0	0.0	1.049	1.085	0.073	1.157	0.808	3.014
Round baler	75	4.020	0.0	0.0	4.020	3.479	0.227	3.706	2.521	10.247
Rotary mower	78	0.126	0.0	0.0	0.126	0.333	0.022	0.355	0.248	0.729
Sprayer-jet	91	0.458	0.0	0.0	0.458	0.309	0.019	0.328	0.206	0.992
Fert-Dist-PTO	92	0.320	0.0	0.0	0.320	0.289	0.019	0.309	0.215	0.844

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[1] Code refers to machinery item number in machinery description table.

[2] Lubricants for machines without engines are included in repair costs.

[3] Total ownership and operating costs equal fixed costs plus interest cost plus variable costs.

Appendix Table 7.—Description of machinery and equipment items used in budget preparations, Red River Valley Experiment Station, 1979

Machine	Code	Size	Purchase Price	Salvage value	Annual hours used	Years owned	Hours life	Performance rate (hours/acre)
			----------------dollars----------------					
Tractor, 31-55 HP	2	43.0^{1}	7,800	1,568	625	16	10,000	1.000
Tractor, 56-80 HP	3	68.0^{1}	12,780	2,543	625	16	10,000	1.000
Tractor, 106-130 HP	5	118.0^{1}	24,773	4,930	625	16	10,000	1.000
Pickup truck	10	0.5^{2}	6,930	2,508	800	6	4,000	1.000
5-Ton truck	12	5.0^{2}	10,890	2,140	400	10	4,000	1.000
Combine, medium	14	16.0^{3}	38,993	8,172	200	10	2,000	0.283
Cotton picker, 2R	16	6.0^{3}	50,567	10,598	200	10	2,000	0.702
Cotton picker, 2R	17	6.0^{3}	50,567	10,598	200	10	2,000	0.573
Disk, 6R	32	21.0^{3}	6,345	1,247	200	10	2,000	0.151
Hipper, 6R	38	21.0^{3}	2,462	484	200	10	2,000	0.134
Chisel plow	45	12.0^{3}	1,530	301	200	10	2,000	0.283
Cultivator, 6R	48	21.0^{3}	2,880	566	200	10	2,000	0.151
Cult-post, 6R	51	21.0^{3}	3,960	778	200	10	2,000	0.179
Planter-pre, 6R	57	21.0^{3}	6,480	1,273	200	10	2,000	0.156
Stalk shredder 2	60	7.0^{3}	1,260	248	150	10	1,500	0.319
Spike harrow, 4R	62	14.0^{3}	450	88	200	10	2,000	0.159
Conditioner, 6R	65	21.0^{3}	3,150	619	200	10	2,000	0.116
Trailer, utility	67	1.0^{3}	720	77	200	15	3,000	1.000
Cotton trailer	68	10.0^{3}	2,700	416	400	12	2,000	1.000
Mower-conditioner	71	9.0^{3}	5,058	994	150	10	1,500	0.191
Hayrake	72	10.0^{3}	1,373	270	150	10	1,500	0.198
Hayfork	73	2.0^{3}	261	51	300	10	3,000	1.000
Grain drill	74	10.0^{3}	2,700	531	200	10	2,000	0.306
Round baler	75	18.0^{3}	6,390	1,172	150	10	1,500	0.204
Rotary mower	78	5.0^{3}	621	122	150	10	2,000	0.407
Sprayer-jet	91	12.0^{3}	495	124	150	8	1,200	1.000
Fert-Dist-PTO	92	20.0^{3}	540	106	150	10	1,500	0.110

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[1] Drawbar Horsepower. [2] Tons. [3] Feet.

Performance of Soybean Varieties in Louisiana, 1975–79

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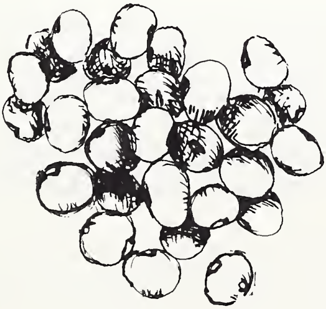

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Center for Agricultural Sciences
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Performance of Soybean Varieties in Louisiana, 1975-79

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D. J. BOQUET[5] AND R. L. HUTCHINSON[5]

Soybean production is one of the leading agricultural industries in Louisiana. In 1979, soybean farmers harvested an estimated 89 million bushels of soybeans from 3.2 million acres (Louisiana Crop and Livestock Reporting Service), compared with 4.7 million bushels harvested from 240,000 acres in 1961. Soybeans were grown on more than twice the combined acreage of cotton, rice, corn, and grain sorghum in 1979. The acreage devoted to soybeans in 1979 represented almost two-thirds of the total cultivated land occupied by agronomic crops in the state.

Because of the importance of soybeans in Louisiana, it was essential that performance trials be conducted throughout the state to aid producers in selecting varieties best adapted for their areas. Soybean variety trials have been conducted at locations representing the major soil and climatic areas of the state for many years. Results of these trials have been published annually in research reports of the individual branch stations and in the Research Report series by the Department of Agronomy, LSU Agricultural Experiment Station.

Soybean varieties do not always respond similarly when grown under different environmental conditions. Therefore, variety comparisons based on results obtained during any 1 year are less reliable than comparisons based on multiple-year results. Consequently, it is desirable to combine individual tests at each location across a number of years for analysis. The primary objectives of this report are to compare the relative adaptation of each of four soybean maturity groups grown in Louisiana, and to compare the average performance of varieties within each maturity group at locations representing the major production areas of the state.

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Materials and Methods

All soybean varieties grown on substantial acreage in Louisiana were included in the trials each year. New varieties were included in the tests as seed became available. Varieties were eliminated from the tests when the acreage they occupied within the state became limited. Agronomic traits and disease reactions of the varieties evaluated are shown in Table 1.

Tests were conducted at the Dean Lee Agricultural Center at Alexandria, the Burden Research Plantation at Baton Rouge, the Red River Valley Experiment Station at Bossier City, the Rice Experiment Station at Crowley, the Macon Ridge Experiment Station at Winnsboro, and on two soil types at the Northeast Louisiana Experiment Station at St. Joseph. Planting date, soil type, and other production data for each test site are shown in Table 2. Cultural practices for the tests conformed closely to those recommended for each production area. Plots were planted with either a two- or four-row planter at a rate of 9 to 12 seeds per linear foot of row. All varieties within a test were planted the same day. Weeds were controlled with herbicides and cultivation. Insecticides were used as needed at all locations. All varieties were harvested at maturity or as soon thereafter as weather conditions permitted.

Characters measured included seed yield, maturity date, plant height at maturity, lodging, shattering, seed quality, and lowest pod height. Yields were determined on combine-run plot weights adjusted to 13 percent moisture at all locations except Baton Rouge, where yields were based on cleaned seed adjusted to 13 percent moisture. Maturity was recorded as the date when the pods were dry and essentially all leaves had fallen. Plant height at maturity was determined as the average height of plants from the ground to the terminal apex. Lodging was recorded using a scale of 1 to 5, with 1 = almost all plants erect: 2 = either all plants leaning slightly, or a few plants lodged; 3 = either all plants leaning moderately, or 25 to 50 percent of the plants lodged; 4 = either all plants leaning considerably, or 50 to 80 percent of the plants lodged, and 5 = all plants lodged.

Shattering was recorded approximately 14 days after maturity on border rows at all locations except Alexandria and St. Joseph. Ratings were assigned on a scale of 1 to 5, where 1 = no shattering, 2 = 1 to 3 percent shattered, 3 = 4 to 8 percent shattered, 4 = 9 to 19 percent shattered, and 5 = more than 20 percent shattered.

Seed quality ratings were assigned on a scale of 1 to 5, where 1 = very good, 2 = good, 3 = fair, 4 = poor, and 5 = very poor quality. Seed development and brightness, seedcoat wrinkling, and disease development also were considered in the seed quality ratings.

Height of lower pods was determined as the average height from the soil to the first pod.

Rainfall was recorded at each location during all 5 years of the study.

Table 1.—Variety descriptive traits and reaction to major soybean pests in Louisiana

Maturity group and variety	Flower color[1]	Pubescence color[2]	Hilum color[3]	Phytophthora root rot[4]	Bacterial pustule[4]	Target spot[4]	Root-knot nematode[4]	Cyst nematode[4] (Race 3)	Reniform nematode[4]
Group V									
Coker 136	P	G	B	S	R	R	S	S	S
Dare	W	G	B	MR	R	MR	MS	S	MR
Forrest	W	Bn	Bk	MR	R	R	R	R	R
Mack	P	Bn	Bk	R	R	R	S	R	S
Group VI									
Centennial	P	Bn	Bk	R	R	R	R	R	R
Davis	W	G	B	R	R	R	S	S	S
Hood 75	P	G	B	R	R	R	S	S	S
Lancer	P	G	Bk	MR	R	R	S	S	S
Lee 74	P	Bn	Bk	R	R	R	R	S	S
Pickett 71	P	G	BnBk	R	R	R	S	R	R
Tracy	W	Bn	Bk	R	R	R	S	S	S
Group VII									
Bragg	W	Bn	Bk	MR	R	R	R	S	MR
Ransom	P	Bn	Bk	VS	R	R	S	S	S
Group VIII									
Coker 338	W	Bn	DkBn	S	R	R	MR	S	S

[1] P = purple, W = white. [2] G = gray, Bn = brown. [3] B = buff, Bk = black, BnBk = brownish black, DkBn = dark brown.

[4] R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible, VS = very susceptible.

Table 2.—Planting date, plot size, fertilizer treatment, and soil type for soybean variety trials, by years

Location	Date planted	Rows planted	Rows harvested	Row length, ft.	Row width, in.	Fertilizer applied	Soil type[1]
			1975				
Alexandria	May 23	4	2	85	40	none	Nr sl lm
Baton Rouge	May 21	4	2	50	40	0-60-60	Ol sl lm
Bossier City	May 23	4	4	100	40	none	Mo sl c
Crowley	May 21	6	4	40	32	0-60-60	Cr sl lm
St. Joseph	May 19	4	4	131	40	none	Co sl lm
St. Joseph	June 3	4	2	16	40	none	Sh c
Winnsboro	May 28	4	4	50	40	12-60-60	Ca sl lm
			1976				
Alexandria	May 18	4	2	79	40	none	Nr sl c lm
Baton Rouge	May 20	4	2	50	40	0-60-60	Ol sl lm
Bossier City	May 20	4	2	100	40	none	Nr sl c lm
Crowley	May 26	6	4	40	32	0-60-60	Cr sl lm
St. Joseph	May 4	4	4	55	40	none	Co sl lm
St. Joseph	May 21	4	4	60	40	none	Sh c
Winnsboro	May 15	4	2	45	40	none	Gr sl lm
			1977				
Alexandria	June 20	4	2	85	40	none	Nr sl lm
Baton Rouge	May 18	4	2	50	40	0-60-60	Ol sl lm
Bossier City	May 13	4	4	75	40	none	Mo sl c
Crowley	May 4	6	4	40	32	0-60-60	Cr sl lm
St. Joseph	May 17	4	4	50	40	none	Co sl lm
St. Joseph	May 13	4	4	60	40	none	Sh c
Winnsboro	May 12	4	2	45	40	none	Gr sl lm
			1978				
Alexandria	May 22	4	2	80	40	none	Nr sl lm
Baton Rouge	May 29	4	2	50	40	0-60-60	Ol sl lm
Bossier City	May 19	4	4	80	40	none	Mo sl c
Crowley	May 26	6	4	35	32	0-60-60	Cr sl lm
St. Joseph	May 19	4	4	55	40	none	Co sl lm
St. Joseph	May 17	4	4	60	40	none	Sh c
Winnsboro	May 16	4	2	45	40	none	Gr sl lm
			1979				
Alexandria	June 8	4	2	80	40	none	Nr sl lm
Baton Rouge	May 17	4	2	45	40	0-60-60	Ol sl lm
Bossier City	May 27	4	4	75	40	none	Mo sl c
Crowley	May 17	6	4	35	32	0-60-60	Cr sl lm
St. Joseph	May 15	4	4	55	40	none	Co sl lm
St. Joseph	May 9	4	4	60	40	none	Sh c
Winnsboro	May 11	4	2	45	40	none	Gr sl lm

[1] Nr = Norwood, Ol = Olivier, Mo = Moreland, Cr = Crowley, Co = Commerce, Sh = Sharkey, Ca = Calloway, and Gr = Grenada; sl lm = silt loam, sl c = silty clay, c = clay, and sl c lm = silty clay loam.

Cumulative rainfall amounts for the months of May through October at each location are shown for each year in Table 3.

Tests were arranged in a randomized block design, with a minimum of four replications per location-year combination. Varieties were ran-

Table 3.—Cumulative precipitation (in inches) for May through October at six locations in Louisiana, 1975-79

Location	Year	Month						Deviation from 20-yr. avg.
		May	June	July	Aug.	Sept.	Oct.	
Alexandria	1975	14.52	9.27	4.58	10.43	4.90	7.89	+25.92
	1976	6.69	5.23	9.11	1.45	2.61	2.52	+ 1.94
	1977	2.91	3.05	3.45	5.94	2.20	4.29	− 3.83
	1978	3.26	3.09	5.26	10.35	3.33	0.36	− 0.02
	1979	3.27	1.65	5.56	3.18	14.24	6.46	+ 8.69
Baton Rouge	1975	6.25	6.16	13.30	7.46	4.89	1.61	+13.89
	1976	6.52	2.69	7.34	8.19	1.68	3.53	+ 4.17
	1977	3.07	0.95	7.19	11.24	13.39	4.99	+15.05
	1978	9.63	4.51	5.80	9.74	4.18	0.00	+ 8.08
	1979	5.82	0.57	10.95	4.37	3.72	1.10	+ 0.75
Bossier City	1975	8.67	5.00	3.81	0.88	2.34	1.97	+ 1.09
	1976	4.56	5.91	5.77	1.90	3.42	1.89	+ 1.87
	1977	1.33	3.00	2.74	4.18	2.31	0.53	− 7.49
	1978	7.73	1.41	3.87	3.34	2.28	2.21	− 0.74
	1979	9.01	2.81	9.77	0.96	2.92	3.46	+ 7.35
Crowley	1975	8.89	6.89	10.07	8.87	2.76	1.78	+ 7.75
	1976	6.13	5.41	5.04	4.71	2.80	2.08	− 5.34
	1977	0.89	3.44	3.81	12.06	3.66	6.49	− 1.16
	1978	2.51	6.75	6.96	3.92	3.41	0.06	− 7.90
	1979	8.38	0.33	8.88	6.13	5.43	1.67	− 0.69
St. Joseph	1975	13.45	7.48	4.45	5.72	4.05	8.95	+22.60
	1976	6.58	2.46	2.81	0.49	4.05	3.43	− 1.68
	1977	3.56	1.44	3.99	5.09	1.75	2.85	− 2.82
	1978	8.39	2.25	2.77	3.49	1.99	0.60	+22.60
	1979	4.39	1.03	7.11	1.01	5.10	3.16	+ 0.30
Winnsboro	1975	10.92	13.20	5.58	4.01	1.99	7.46	+21.51
	1976	7.70	5.81	2.48	0.86	0.97	1.67	− 2.16
	1977	1.43	1.30	3.72	1.84	0.70	2.36	−10.30
	1978	8.37	2.30	1.59	3.63	1.25	0.51	− 4.00
	1979	5.45	1.37	5.32	2.86	7.48	3.43	+ 4.26

domized within maturity groups. However, due to the absence of some varieties from certain location-year combinations and because one maturity group contained only one variety, the variety source of variation was not partitioned in the overall analysis of variance. Yield data from individual tests were analyzed using standard analysis of variance procedures. Twenty to 28 varieties were evaluated in the tests each year; however, 14 varieties were included in all 5 years of the study. Yield data from these 14 varieties were analyzed in a combined analysis using a fixed model. Orthogonal contrasts were made combining the appropriate varieties so comparisons could be made among maturity group means averaged across years for each location. All other means were compared using Duncan's New Multiple Range Test at the .05 probability level.

Results and Discussion

Mean squares from the combined analysis for yield were highly significant for all main effects and interactions (Table 4). These effects were expected since climatic conditions were quite variable in some years, the varieties represented a wide range in maturity, and the locations were selected because of diverse soil and environmental conditions.

Table 4.—Combined analysis of variance for yield of 14 soybean varieties grown at seven locations in Louisiana, 1975-79

Source	df	MS
Total	1,992	
Year	4	7,012.90**
Location	6	16,704.78**
Year x location	24	2,962.51**
Error a	105	68.02
Variety	13	563.69**
Year x variety	52	76.68**
Location x variety	78	169.81**
Error b	1,710	28.54

**Significant at the .01 probability level.

When averaged across years and locations, Forrest was significantly higher in yield than other Group V varieties, and Coker 136 was significantly higher in yield than both Dare and Mack (Table 5). Tracy was the highest yielding Group VI variety and significantly outyielded both Hood 75 and Lee 74. The Group VII varieties, Bragg and Ransom, had very similar yields, 39.8 and 39.4 bushels, respectively, as an average across all tests.

Mean soybean yields for locations ranged from 47.2 bushels at Alexandria to 25.6 bushels at Winnsboro (Table 6). Mean yields were similar at Baton Rouge, Bossier City, Crowley, and on Sharkey clay at St. Joseph. However, yields at St. Joseph were significantly higher on Commerce silt loam than on Sharkey clay. When averaged across varieties and locations, mean yields were highest in 1975 and lowest in 1977 (Table 7). Rainfall amounts and distribution during the growing season generally were good in 1975 and 1979, moderate in 1976, and limited in 1977 and 1978 (Table 3). Yields for the varieties in each of the 5 years are shown in Table 8.

Differences among varieties were apparent for plant height, lodging, shattering, and seed quality (Table 5), and many of the characters were affected differentially by location (Table 6). The varieties tended to shatter more and have less seed damage at the central and northern locations than at southern locations. One exception was on Sharkey clay at St. Joseph, where seed damage was quite severe (Table 6).

Table 5.—Mean yield, maturity date, mature plant height, lodging, shattering, visual seed quality, and lower pod height of 14 soybean varieties as an average of locations and years

Maturity group and variety	Yield, bu./ac.[1]	Maturity date	Plant height, in.	Lodging[2]	Shattering[3]	Seed quality[4]	Height of lower pods, in.
Group V							
Forrest	38.2c	Sept. 24	30	1.5	1.2	2.1	4.4
Coker 136	36.0d	Sept. 25	32	1.5	1.1	2.0	5.0
Dare	34.9e	Sept. 23	29	1.5	1.2	1.9	4.2
Mack	34.2e	Sept. 23	28	2.0	1.6	2.2	4.1
Group VI							
Tracy	40.1a	Oct. 9	34	2.0	1.2	2.1	4.8
Davis	39.4ab	Oct. 8	35	2.0	1.7	1.7	5.0
Lancer	39.4ab	Oct. 5	33	1.4	1.1	1.9	5.4
Centennial	39.2ab	Oct. 13	34	1.6	1.2	1.8	4.9
Pickett 71	39.1a-c	Oct. 13	30	1.7	1.3	1.8	4.7
Hood 75	38.7bc	Sept. 30	29	1.6	1.8	1.9	4.5
Lee 74	38.4bc	Oct. 15	30	1.7	1.3	1.8	4.6
Group VII							
Bragg	39.8a	Oct. 21	39	2.1	1.0	1.9	6.0
Ransom	39.4ab	Oct. 20	33	1.5	1.1	1.8	5.8
Group VIII							
Coker 338	39.9a	Oct. 27	38	1.9	1.1	1.9	6.3

[1] Means followed by the same letter are not significantly different at the .05 probability level according to Duncan's New Multiple Range Test.

[2] 1 = no lodging, 5 = all plants lodged.

[3] 1 = no shattering, 5 = more than 20% seed shattered.

[4] 1= very good quality, 5 = very poor quality.

Table 6.—Mean yield, maturity date, mature plant height, lodging, shattering, visual seed quality, and lower pod height at seven locations in Louisiana as an average of 14 soybean varieties and 5 years

Location	Yield, bu./ac.	Maturity date	Plant height, in.	Lodging[1]	Shattering[2]	Seed quality[3]	Height of lower pod, in.
Alexandria	47.2a[4]	Oct. 7	36	1.6	—	1.7	5.4
St. Joseph—CSL[5]	46.1b	Oct. 5	36	2.1	—	1.9	5.3
St. Joseph—SC[5]	38.5c	Oct. 7	29	1.4	—	2.1	3.1
Baton Rouge	38.1c	Oct. 11	36	2.5	1.1	2.1	5.4
Bossier City	38.0c	Oct. 8	29	1.8	1.3	1.2	5.7
Crowley	37.9c	Oct. 10	28	1.5	1.2	2.5	5.5
Winnsboro	25.6d	Oct. 6	32	1.2	1.5	1.8	4.5

[1] 1 = no lodging, 5 = all plants lodged.

[2] 1 = no shattering, 5 = more than 20% seed shattered.

[3] 1 = very good quality, 5 = very poor quality.

[4] Means followed by the same letter are not significantly different at the .05 probability level according to Duncan's New Multiple Range Test.

[5] CSL = Commerce silt loam, SC = Sharkey clay.

Table 7.—Mean yield, maturity date, mature plant height, lodging, shattering, visual seed quality, and lower pod height by years as an average of 14 soybean varieties and seven locations

Year	Yield, bu./ac.	Maturity date	Plant height, in.	Lodging[1]	Shattering[2]	Seed quality[3]	Height of lower pod, in.
1975	43.2a[4]	Oct. 9	32	1.6	1.0	2.0	5.1
1979	41.7b	Oct. 7	31	1.6	1.3	2.0	4.7
1976	38.9c	Oct. 7	36	1.9	1.1	1.8	5.7
1978	34.4d	Oct. 7	30	1.8	1.5	2.1	4.6
1977	33.3e	Oct. 6	32	1.8	1.1	1.9	5.1

[1] 1 = no lodging, 5 = all plants lodged.

[2] 1 = no shattering, 5 = more than 20% seed shattered.

[3] 1 = very good quality, 5 = very poor quality.

[4] Means followed by the same letter are not significantly different at the .05 probability level according to Duncan's New Multiple Range Test.

Table 8.—Mean yield of 14 soybean varieties by years as an average of seven locations

Maturity group and variety	Year 1975	1976	1977	1978	1979
	Bushels per acre				
Group V					
Forrest	41.0ef[1]	36.5e	35.9a	33.6de	43.5b
Coker 136	40.1fg	37.2de	32.8cd	32.1e	37.9c
Dare	39.4fg	33.7f	32.1cd	29.9f	38.8c
Mack	38.6g	34.5f	32.1cd	28.2f	37.5c
Group VI					
Tracy	46.7a	40.8a-c	33.8a-d	37.0b	43.0b
Davis	46.0ab	40.2a-c	32.6cd	35.2b-d	42.4b
Lancer	45.8ab	38.6cd	34.4a-c	35.9bc	42.0b
Centennial	43.2cd	39.8a-c	33.4b-d	36.9b	43.3b
Pickett 71	44.6a-d	41.5ab	32.0d	36.2b	41.2b
Hood 75	43.5cd	38.9cd	35.6ab	32.1e	43.0b
Lee 74	42.5de	42.0a	32.9cd	35.4b-d	39.1c
Group VII					
Bragg	44.9a-c	39.4b-d	32.6cd	35.9bc	45.6a
Ransom	44.6a-d	42.0a	32.7cd	33.9c-e	43.3b
Group VIII					
Coker 338	43.8b-d	39.3b-d	33.6b-d	39.0a	43.3b

[1] Means within columns followed by the same letter are not significantly different at the .05 probability level according to Duncan's New Multiple Range Test.

Comparisons were made among maturity groups to determine their relative adaptation at each location (Table 9). Mean yields were significantly higher for Maturity Group VIII, which included only Coker 338, than for the other maturity groups at Alexandria, Bossier City, and on Commerce silt loam at St. Joseph. The Group VIII variety also had the highest mean yield on Sharkey clay at St. Joseph. Group VIII varieties

Table 9.—Mean yield of four maturity groups at seven locations as an average of 5 years

Maturity group	Alexandria	Baton Rouge	Bossier City	Crowley	St. Joseph CSL	St. Joseph SC[1]	Winnsboro
	Bushels per acre						
Group V	45.3c[2]	35.5c	31.6c	37.8ab	46.3b	31.6c	25.6a
Group VI	47.3b	38.5b	40.0b	38.6a	45.5b	41.7a	25.9a
Group VII	48.5b	41.9a	41.9ab	36.8b	45.9b	39.6b	25.7a
Group VIII	51.4a	38.8b	42.5a	32.5c	49.3a	42.2a	23.5b

[1] CSL = Commerce silt loam, SC = Sharkey clay.

[2] Means were separated using orthogonal contrasts.

normally are 7 to 10 days later in maturity than Group VII varieties (Table 5), which often causes harvesting and seed quality problems, especially during years of excessive late-season precipitation. Mean yields of Group V varieties were significantly lower than yields of the other maturity groups at Alexandria, Baton Rouge, Bossier City, and on Sharkey clay at St. Joseph. This indicated that Group V varieties generally were less adapted to these locations than were the later maturing varieties. Because of their shorter maturation period, Group V varieties apparently have less time to compensate for environmental extremes, such as moisture stress or excess, than do varieties of later maturity. Mean yields for varieties within each maturity group are shown for each location in Table 10.

Since differences among varieties may vary under different environmental conditions (Table 4), and because sufficient technology is not available to accurately predict weather conditions, the most precise method for determining variety adaptation to a certain area is to consider relative performance based on multiple-year averages. For this purpose, 5-year average performance means for each variety for the individual locations are shown in Tables 11 through 17. Forrest had the highest mean yield of the Group V varieties at Baton Rouge, Crowley, and on both soil types at St. Joseph. Coker 136, Dare, and Mack had the highest yields at Alexandria, Bossier City, and Winnsboro, respectively. Leading varieties within Maturity Group VI were Centennial at Baton Rouge, Hood 75 at Crowley, Davis on Sharkey clay at St. Joseph, and Lancer at Bossier City and on Commerce silt loam at St. Joseph. There were no significant differences in yield among Group VI varieties at Alexandria. Of the Group VII varieties, Ransom was significantly higher in yield than Bragg at Baton Rouge and Winnsboro; however, Bragg significantly outyielded Ransom on Sharkey clay at St. Joseph. Differences in yield between the two Group VII varieties were not significant at any other location.

Table 10.—Mean yield of 14 soybean varieties by location as an average of 5 years

Maturity group and variety	Alexandria	Baton Rouge	Bossier City	Crowley	St. Joseph CSL	St. Joseph SC[1]	Winnsboro
	Bushels per acre						
Group V							
Forrest	46.9c[2]	40.6bc	31.8f	40.8a	49.7a	33.7d	27.2ab
Coker 136	47.5bc	35.7fg	32.8f	38.1b-d	48.3ab	29.7e	23.4d
Dare	44.0de	34.7g	32.9f	36.7c-e	42.9fg	31.0e	24.5b-d
Mack	42.7e	30.8h	28.8g	35.8de	44.1d-g	32.1de	27.4a
Group VI							
Tracy	47.7bc	39.2b-e	41.6a-d	39.6ab	46.4b-d	42.8b	27.2ab
Davis	46.3c	35.9fg	40.2a-d	37.7b-e	46.1b-d	45.6a	26.6a-c
Lancer	47.8bc	36.8e-g	42.6a	39.3a-c	49.1a	37.1c	26.1a-d
Centennial	47.8bc	41.5ab	39.6c-e	38.0b-d	43.3e-g	43.6ab	25.2a-d
Pickett 71	48.3bc	40.4b-d	39.9b-e	37.1b-e	41.6g	43.7ab	25.9a-d
Hood 75	46.8c	37-9d-f	37.5e	40.9a	46.5b-d	37.8c	26.3a-c
Lee 74	46.2cd	37.8ef	39.1de	37.2b-e	45.7b-e	41.6b	24.1cd
Group VII							
Bragg	49.8ab	40.5bc	41.8a-c	36.0de	47.2a-c	43.1ab	23.9cd
Ransom	47.2bc	43.4a	42.0a-c	37.6b-e	44.6c-f	36.2c	27.5a
Group VIII							
Coker 338	51.4a	38.8c-e	42.5ab	35.2e	49.3a	42.2b	23.5d

[1] CSL = Commerce silt loam, SC = Sharkey clay.

[2] Means within columns followed by the same letter are not significantly different at the .05 probability level according to Duncan's New Multiple Range Test.

Table 11.—Performance of 14 soybean varieties at Alexandria, 1975-79

Maturity group and variety	Yield, bu./ac.	Maturity date	Plant height, in.	Lodging[1]	Seed quality[2]	Height of lower pods, in.
Group V						
Coker 136	47.5bc[3]	Sept. 27	36	1.8	1.7	5
Forrest	46.9c	Sept. 24	34	1.5	1.7	4
Dare	44.0de	Sept. 19	33	1.5	1.6	5
Mack	42.7e	Sept. 24	33	1.7	2.0	5
Group VI						
Pickett 71	48.3bc	Oct. 10	35	1.6	1.5	5
Centennial	47.8bc	Oct. 12	37	1.2	1.5	6
Lancer	47.8bc	Oct. 6	38	1.5	1.6	6
Tracy	47.7bc	Oct. 5	36	2.3	1.9	5
Hood 75	46.8c	Sept. 29	34	1.5	1.7	5
Davis	46.3c	Oct. 8	39	1.5	1.5	6
Lee 74	46.2cd	Oct. 14	34	1.6	1.7	5
Group VII						
Bragg	49.8ab	Oct. 19	41	1.3	1.7	7
Ransom	47.2bc	Oct. 18	37	1.2	1.6	6
Group VIII						
Coker 338	41.4a	Oct. 28	40	1.5	1.9	7

[1] 1 = no lodging, 5 = all plants lodged.

[2] 1 = very good quality, 5 = very poor quality.

[3] Means followed by the same letter are not significantly different at the .05 probability level according to Duncan's New Multiple Range Test.

Table 12.—Performance of 14 soybean varieties at Baton Rouge, 1975-79

Maturity group and variety	Yield, bu./ac.	Maturity date	Plant height, in.	Lodging[1]	Seed quality[2]	Shattering[3]	Height of lower pods, in.
Group V							
Forrest	40.6bc[4]	Sept. 25	33	2.3	2.2	1.0	5
Coker 136	35.7fg	Sept. 27	35	1.9	2.7	1.2	6
Dare	34.7g	Sept. 26	32	1.9	2.2	1.0	5
Mack	30.8h	Sept. 27	32	3.0	3.3	1.1	5
Group VI							
Centennial	41.5ab	Oct. 14	39	2.6	1.9	1.0	5
Pickett 71	40.4b-d	Oct. 18	33	2.8	1.9	1.0	5
Tracy	39.2b-e	Oct. 16	37	3.2	2.1	1.0	5
Hood 75	37.9d-f	Oct. 2	32	2.2	2.0	1.0	5
Lee 74	37.8ef	Oct. 15	34	2.6	2.0	1.0	6
Lancer	36.8e-g	Oct. 6	38	1.8	1.8	1.0	6
Davis	35.9fg	Oct. 12	38	2.6	2.0	1.4	5
Group VII							
Ransom	43.4a	Oct. 27	37	2.3	2.1	1.0	6
Bragg	40.5bc	Oct. 27	43	3.3	1.8	1.0	6
Group VIII							
Coker 338	38.8c-e	Nov. 1	43	2.9	1.9	1.0	7

[1] 1 = no lodging, 5 = all plants lodged.

[2] 1 = very good quality, 5 = very poor quality.

[3] 1 = no shattering, 5 = more than 20% seed shattered.

[4] Means followed by the same letter are not significantly different at the .05 probability level according to Duncan's New Multiple Range Test.

Table 13.—Performance of 14 soybean varieties at Bossier City, 1975-79

Maturity group and variety	Yield, bu./ac.	Maturity date	Plant height, in.	Lodging[1]	Seed quality[2]	Shattering[3]	Height of lower pods, in.
Group V							
Dare	32.9f[4]	Sept. 24	26	1.5	1.2	1.5	5
Coker 136	32.8f	Sept. 26	28	1.4	1.3	1.0	6
Forrest	31.8f	Sept. 26	28	1.5	1.7	1.8	5
Mack	28.8g	Sept. 24	24	1.7	1.3	2.2	5
Group VI							
Lancer	42.6a	Oct. 6	29	1.5	1.3	1.0	6
Tracy	41.6a-d	Oct. 5	30	1.8	1.5	1.0	5
Davis	40.2a-d	Oct. 6	29	2.0	1.0	1.0	5
Pickett 71	39.9b-e	Oct. 11	28	1.8	1.2	1.0	5
Centennial	39.6c-e	Oct. 8	28	1.7	1.0	1.0	6
Lee 74	39.1de	Oct. 13	29	1.7	1.0	1.0	5
Hood 75	37.5e	Oct. 3	25	1.7	1.2	1.8	5
Group VII							
Ransom	42.0a-c	Oct. 19	31	1.7	1.0	1.0	6
Bragg	41.8a-c	Oct. 19	35	2.3	1.0	1.0	7
Group VIII							
Coker 338	42.5ab	Oct. 24	34	2.3	1.2	1.0	7

[1] 1 = no lodging, 5 = all plants lodged.

[2] 1 = very good quality, 5 = very poor quality.

[3] 1 = no shattering, 5 = more than 20% seed shattered.

[4] Means followed by the same letter are not significantly different at the .05 probability level according to Duncan's New Multiple Range Test.

Table 14.—Performance of 14 soybean varieties at Crowley, 1975-79

Maturity group and variety	Yield, bu./ac.	Maturity date	Plant height, in.	Lodging[1]	Seed quality[2]	Shattering[3]	Height of lower pods, in.
Group V							
Forrest	40.8a[4]	Sept. 23	26	1.3	2.1	1.0	6
Coker 136	38.1b-d	Sept. 23	25	1.3	2.1	1.0	6
Dare	36.7c-e	Sept. 21	24	1.3	2.0	1.0	5
Mack	35.8de	Sept. 24	25	2.5	2.6	1.5	5
Group VI							
Hood 75	40.9a	Sept. 30	24	1.7	2.4	1.5	6
Tracy	39.6ab	Oct. 13	29	1.5	2.9	1.5	5
Lancer	39.3a-c	Oct. 5	28	1.2	2.5	1.5	6
Centennial	38.0b-d	Oct. 18	30	1.4	2.6	1.0	5
Davis	37.7b-e	Oct. 11	30	1.7	2.2	1.8	6
Lee 74	37.2b-e	Oct. 20	25	1.3	2.1	1.0	5
Pickett 71	37.1b-e	Oct. 14	25	1.3	2.2	1.0	5
Group VII							
Ransom	37.6b-e	Oct. 26	29	1.2	2.6	1.3	6
Bragg	36.0de	Oct. 27	34	1.9	3.3	1.0	6
Group VIII							
Coker 338	35.2e	Nov. 1	32	1.6	2.7	1.0	6

[1] 1 = no lodging, 5 = all plants lodged.

[2] 1 = very good quality, 5 = very poor quality.

[3] 1 = no shattering, 5 = more than 20% seed shattered.

[4] Means followed by the same letter are not significantly different at the .05 probability level according to Duncan's New Multiple Range Test.

Table 15.—Performance of 14 soybean varieties on Commerce silt loam, St. Joseph, 1975-79

Maturity group and variety	Yield, bu./ac.	Maturity date	Plant height, in.	Lodging[1]	Seed quality[2]	Height of lower pods, in.
Group V						
Forrest	49.7a[3]	Sept. 22	33	1.5	2.4	4
Coker 136	48.3ab	Sept. 24	38	1.7	2.0	5
Mack	44.1d-g	Sept. 20	30	2.3	2.2	4
Dare	42.9fg	Sept. 23	32	2.0	2.1	4
Group VI						
Lancer	49.1a	Oct. 3	37	1.9	1.9	6
Hood 75	46.5b-d	Sept. 26	32	2.0	2.0	5
Tracy	46.4b-d	Oct. 4	36	2.1	1.9	5
Davis	46.1b-d	Oct. 8	39	2.5	1.8	6
Lee 74	45.7b-e	Oct. 15	31	1.9	1.9	5
Centennial	43.3e-g	Oct. 10	38	2.1	1.7	6
Pickett 71	41.6g	Oct. 11	32	1.9	1.8	5
Group VII						
Bragg	47.2a-c	Oct. 18	41	2.4	1.9	7
Ransom	44.6c-f	Oct. 16	35	1.9	1.8	7
Group VIII						
Coker 338	49.3a	Oct. 23	43	2.4	1.7	7

[1] 1 = no lodging, 5 = all plants lodged.

[2] 1 = very good quality, 5 = very poor quality.

[3] Means followed by the same letter are not significantly different at the .05 probability level according to Duncan's New Multiple Range Test.

Table 16.—Performance of 14 soybean varieties on Sharkey clay, St. Joseph, 1975-79

Maturity group and variety	Yield, bu./ac.	Maturity date	Plant height, in.	Lodging[1]	Seed quality[2]	Height of lower pods, in.
Group V						
Forrest	33.7d[3]	Sept. 23	25	1.4	2.7	3
Mack	32.1de	Sept. 22	24	1.7	2.4	2
Dare	31.0e	Sept. 23	25	1.1	2.1	3
Coker 136	29.7e	Sept. 24	29	1.1	2.2	4
Group VI						
Davis	45.6a	Oct. 9	34	1.9	2.1	3
Pickett 71	43.7ab	Oct. 14	24	1.4	2.0	2
Centennial	43.6ab	Oct. 14	31	1.3	1.9	2
Tracy	42.8b	Oct. 8	33	1.5	2.4	4
Lee 74	41.6b	Oct. 16	25	1.3	1.9	2
Hood 75	37.8c	Sept. 28	27	1.2	2.2	3
Lancer	37.1c	Oct. 3	28	1.0	2.3	4
Group VII						
Bragg	43.1ab	Oct. 19	37	1.9	1.8	5
Ransom	36.2c	Oct. 18	31	1.4	1.8	4
Group VIII						
Coker 338	42.2b	Oct. 26	36	1.5	2.0	4

[1] 1 = no lodging, 5 = all plants lodged.

[2] 1 = very good quality, 5 = very poor quality.

[3] Means followed by the same letter are not significantly different at the .05 probability level according to Duncan's New Multiple Range Test.

Table 17.—Performance of 14 soybean varieties at Winnsboro, 1975-79

Maturity group and variety	Yield, bu./ac.	Maturity date	Plant height, in.	Lodging[1]	Seed quality[2]	Shattering[3]	Height of lower pods, in.
Group V							
Mack	27.4a[4]	Sept. 17	29	1.4	1.7	1.5	3
Forrest	27.2ab	Sept. 22	30	1.0	2.1	1.0	4
Dare	24.5b-d	Sept. 22	28	1.0	1.9	1.0	4
Coker 136	23.4d	Sept. 27	32	1.1	1.6	1.0	4
Group VI							
Tracy	27.2ab	Oct. 11	34	1.5	2.1	1.3	4
Davis	26.6a-c	Oct. 4	37	1.6	1.6	2.4	5
Hood 75	26.3a-c	Sept. 30	28	1.2	1.9	2.9	4
Lancer	26.1a-d	Oct. 9	31	1.0	2.1	1.0	4
Pickett 71	25.9a-d	Oct. 14	30	1.0	1.7	2.0	5
Centennial	25.2a-d	Oct. 12	33	1.0	1.6	1.8	5
Lee 74	24.1cd	Oct. 14	30	1.6	1.6	2.2	4
Group VII							
Ransom	27.5a	Oct. 17	33	1.0	1.4	1.0	5
Bragg	23.9cd	Oct. 17	40	1.5	2.1	1.0	5
Group VIII							
Coker 338	23.5d	Oct. 23	38	1.2	1.9	1.3	7

[1] 1 = no lodging, 5 = all plants lodged.

[2] 1 = very good quality, 5 = very poor quality.

[3] 1 = no shattering, 5 = more than 20% seed shattered.

[4] Means followed by the same letter are not significantly different at the .05 probability level according to Duncan's New Multiple Range Test.

Although 14 varieties were evaluated during all years, varieties that were released during the course of the study, as well as older varieties that were discontinued when replaced by new varieties or when the acreage they occupied in the state became limited, also were tested during 1 or more years. Mean yields for all varieties evaluated each year are shown by location in Tables 18 through 24.

Table 18.—Mean yield of soybean varieties at Alexandria, 1975-79

Maturity group and variety	Year				
	1975	1976	1977	1978	1979
	Bushels per acre				
Group V					
Forrest	49.6c-g[1]	56.4ef	35.2c-e	51.5ab	44.2b-f
Coker 136	50.9a-f	61.6a-e	37.2bc	50.5a-c	42.8d-f
Dare	48.9d-g	54.5fg	35.4c-e	49.6a-f	36.2g
Essex	48.4e-g	—	—	—	—
Mack	46.3g	48.0h	33.7ef	47.9b-e	39.9fg
Hill	42.0h	50.5gh	36.3b-e	42.1fg	—
McNair 500	—	61.3a-e	36.3b-e	49.7a-c	41.1e-g
Deltapine 345	—	—	—	—	43.1d-f
Wilstar 550	—	—	—	—	39.4fg
Group VI					
Lee 68	55.0ab	61.8a-e	—	—	—
Tracy	53.6a-d	64.5ab	35.2c-e	44.4d-g	45.0a-f
McNair 600	53.6a-d	63.2a-d	29.2hi	41.1g	—
Pickett 71	52.7a-e	61.5a-e	36.8b-d	47.3b-e	44.7b-f
Lancer	51.7a-f	61.1a-e	36.8b-d	50.4a-c	43.0d-f
Hood	51.4a-f	61.6a-e	—	—	—
Lee 74	50.3b-g	59.6b-f	35.1c-e	44.4d-g	45.7a-f
Davis	47.4fg	62.2a-e	30.7gh	50.9ab	42.3d-g
Hood 75	—	65.9a	34.3d-f	43.5e-g	43.5c-f
Centennial	—	63.1a-d	34.1d-f	49.0a-d	48.5a-d
Brysoy 9	—	—	—	48.6b-e	42.4d-f
Coker 156	—	—	—	—	46.8a-e
Tracy-M	—	—	—	—	45.7a-f
Terra-Vig 606	—	—	—	—	44.9a-f
Group VII					
Bragg	54.7ab	62.3a-e	36.8b-d	50.7a-c	47.2a-e
McNair 800	55.6a	60.3a-e	27.4i	—	—
Bossier	54.2a-c	60.5a-e	38.6b	—	—
Ransom	53.0a-e	58.0c-f	35.5c-e	44.2e-g	50.6ab
Semmes	52.1a-e	57.3d-f	32.4fg	—	—
Terra-Vig 708	—	—	36.6b-d	54.0a	49.0a-d
McNair 710	—	—	—	46.9b-f	47.0a-e
Coker 237	—	—	—	45.6c-g	47.6a-e
Agripro AP70	—	—	—	45.6c-g	48.6a-d
Wilstar 790	—	—	—	45.5c-g	48.1a-d
Group VIII					
Coker 338	53.2a-d	63.7a-c	44.2a	47.2b-f	51.6a
Coker 488	—	—	—	49.7a-c	50.0a-c
C.V.(%)	5.4	5.3	4.8	6.5	8.7

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[1] Means within columns followed by the same letter are not significantly different at the .05 probability level according to Duncan's New Multiple Range Test.

Table 19.—Mean yield of soybean varieties at Baton Rouge, 1975-79

Maturity group and variety	Year				
	1975	1976	1977	1978	1979
	Bushels per acre				
Group V					
Forrest	37.7d-f[1]	47.1a-e	38.1a	39.5a-e	41.0a-c
Coker 136	36.1ef	46.1a-g	28.6b-e	37.3b-e	30.3ef
Dare	34.3f	40.0g	32.7a-c	35.1d-f	31.5d-f
Mack	26.6g	40.5fg	27.8b-e	30.0fg	28.8f
Hill	19.9h	31.4h	25.3c-e	25.9g	39.9b-f
McNair 500	—	48.1a-d	31.4a-d	36.0c-f	33.9b-f
Deltapine 345	—	—	—	—	36.6a-f
Wilstar 550	—	—	—	—	36.4a-f
Group VI					
Pickett 71	43.9bc	47.1a-e	30.4b-e	41.2a-d	39.6a-d
Lee 74	42.9bc	46.1a-g	30.1b-e	35.4d-f	34.2b-f
Lee 68	42.3bc	47.1a-e	—	—	—
McNair 600	41.7b-d	48.6a-c	30.8b-e	38.4b-e	—
Centennial	41.6b-d	48.8ab	30.9a-e	41.7a-c	44.3a
Tracy	41.1b-d	43.0b-g	33.1ab	38.0b-e	41.2a-c
Hood 75	40.6b-d	43.5b-g	32.6a-c	33.3ef	40.2a-d
Lancer	40.3c-e	42.3c-g	30.1b-e	34.1ef	36.7a-f
Davis	39.9c-e	42.0d-g	24.8de	35.0d-f	37.9a-e
Brysoy 9	—	—	—	38.2b-e	37.4a-e
Coker 156	—	—	—	—	43.2a
Group VII					
Ransom	48.6a	48.8ab	34.0ab	45.2a	40.5a-c
McNair 800	44.9ab	42.1d-g	27.3b-e	—	—
Bossier	44.4bc	50.1a	29.6b-e	—	—
Bragg	43.9bc	47.9a-d	33.1ab	40.4a-d	37.6a-e
Semmes	40.3c-e	40.7e-g	26.7b-e	—	—
Terra-Vig 708	—	—	33.9ab	44.9a	42.7ab
Wilstar 790	—	—	—	42.1a-c	41.7a-c
Coker 237	—	—	—	40.8a-d	40.9a-c
McNair 710	—	—	—	39.5a-e	37.5a-e
Agripro AP 70	—	—	—	38.5b-e	41.3a-c
Group VIII					
Hutton	43.4bc	46.6a-f	30.4b-e	—	—
Coker 338	41.6b-d	42.3c-g	31.5a-d	42.6ab	35.5a-f
Cobb	41.0b-d	41.8d-g	23.7e	—	—
Coker 488	—	—	—	36.4b-e	33.7c-f
C.V.(%)	6.6	8.2	14.3	9.7	13.5

[1] Means within columns followed by the same letter are not significantly different at the .05 probability level according to Duncan's New Multiple Range Test.

Table 20.—Mean yield of soybean varieties at Bossier City, 1975-79

Maturity group and variety	Year				
	1975	1976	1977	1978	1979
	Bushels per acre				
Group V					
Coker 136	49.0b-d[1]	33.5a-d	23.3fg	30.6e-g	28.5f
Dare	46.8b-e	30.5c-e	21.0fg	26.5gh	39.6b-e
Forrest	40.8d-g	32.5b-d	24.7e-g	27.9f-h	33.6ef
Essex	38.7e-g	—	—	—	—
Mack	37.6fg	32.2b-e	19.9g	20.7hi	35.2d-f
Hill	31.8g	23.6e	13.4h	15.1i	—
McNair 500	—	29.2de	24.5e-g	31.3c-g	35.2d-f
Wilstar 550	—	—	—	—	40.0b-e
Deltapine 345	—	—	—	—	39.2b-e
Group VI					
Davis	60.7a	35.5a-d	24.5e-g	40.9a-e	39.2b-e
Lee 68	53.9a-c	40.7ab	—	—	—
Lancer	53.0a-c	41.0ab	32.6a-d	41.2a-d	45.2a-d
McNair 600	52.8a-c	39.9a-c	32.8a-d	41.7a-c	—
Centennial	52.0a-c	42.7a	31.1b-e	36.8b-f	35.4d-f
Lee 74	51.7a-c	42.5a	24.4e-g	39.0b-e	36.3b-f
Hood	51.4a-c	37.5a-d	—	—	—
Tracy	51.2a-c	—	35.7a-c	42.4ab	37.9b-f
Pickett 71	50.4bc	38.9a-d	27.6d-f	40.3b-e	41.2a-e
Curtis	46.0c-f	—	32.9a-d	—	—
Hood 75	—	37.2a-d	30.5c-e	30.9d-g	38.3b-f
Brysoy 9	—	—	—	41.0a-e	35.8c-f
Coker 156	—	—	—	—	49.9a
Group VII					
Ransom	56.6ab	41.6ab	31.7a-d	37.2b-f	42.3a-e
Bossier	55.8a-c	43.0a	38.0ab	40.1b-e	38.5b-f
McNair 800	54.4a-c	43.2a	34.9a-c	—	—
Semmes	52.5a-c	—	38.8a	—	—
Bragg	49.5b-d	40.5ab	35.2a-c	39.4b-e	46.5ab
Terra-Vig 708	—	—	35.6a-c	37.4b-f	43.3a-e
Agripro AP 70	—	—	—	41.6a-c	50.3a
Wilstar 790	—	—	—	40.3b-e	45.9a-c
Coker 237	—	—	—	37.7b-f	35.4d-f
McNair 710	—	—	—	37.0b-f	36.0c-f
Group VIII					
Coker 338	50.1b-d	37.1a	35.0a-c	50.8a	38.2b-f
Cobb	—	41.5ab	36.7a-c	—	—
Hutton	—	37.0a	—	—	—
Coker 488	—	—	—	43.2ab	28.5f
C.V.(%)	11.8	16.6	15.4	18.9	15.3

[1] Means within columns followed by the same letter are not significantly different at the .05 probability level according to Duncan's New Multiple Range Test.

Table 21.—Mean yield of soybean varieties at Crowley, 1975-79

Maturity group and variety	Year				
	1975	1976	1977	1978	1979
	Bushels per acre				
Group V					
Forrest	40.0a-d[1]	46.7ab	43.4a	26.2c-e	47.6ab
Essex	37.1b-d	—	—	—	—
Coker 136	36.8b-d	44.2a-c	40.9a-c	24.2d-f	44.2a-c
Mack	35.2c-e	39.4bc	41.5ab	20.8e-g	41.9bc
Dare	34.1de	46.0a-c	40.5a-c	19.1fg	43.6a-c
Hill	32.2de	36.9c	35.2b-f	18.1g	—
McNair 500	—	46.0a-c	39.5a-d	31.8a-c	43.4a-c
Deltapine 345	—	—	—	—	47.2ab
Wilstar 550	—	—	—	—	39.5bc
Group VI					
Tracy	47.4a	45.4a-c	32.2ef	32.5a-c	40.4bc
McNair 600	44.5ab	42.7a-c	30.9f	30.2a-d	—
Pickett 71	44.8ab	43.0a-c	30.3f	28.1b-d	39.6bc
Davis	44.5ab	43.3a-c	29.5f	30.2a-d	41.3bc
Lancer	43.2a-c	46.1a-c	30.9f	31.7a-c	44.5a-c
Lee 68	42.8a-c	46.2a-c	—	—	—
Hood	37.8b-d	46.9ab	—	—	—
Lee 74	31.8de	41.6a-c	37.5a-e	32.4a-c	37.9c
Hood 75	—	50.5a	37.6a-e	31.3a-c	47.6ab
Centennial	—	41.2a-c	37.5a-e	30.6a-c	42.6bc
Brysoy 9	—	—	—	31.3a-c	39.6bc
Coker 156	—	—	—	—	44.7a-c
Group VII					
Bragg	43.3a-c	24.8d	33.4d-f	30.8a-c	47.5ab
Ransom	39.9a-d	41.3a-c	34.9c-f	31.2a-c	40.6bc
Semmes	31.6de	38.6bc	33.3d-f	—	—
Bossier	27.8e	39.1bc	32.2ef	—	—
McNair 800	27.4e	40.4bc	32.2ef	—	—
Terra-Vig 708	—	—	42.1a	36.0a	42.0bc
Wilstar 790	—	—	—	36.7a	44.5a-c
Coker 237	—	—	—	36.4a	50.8a
McNair 710	—	—	—	33.2ab	44.1a-c
Agripro AP 70	—	—	—	32.0a-c	45.0a-c
Group VIII					
Cobb	40.0a-d	12.4e	22.0g	—	—
Coker 338	35.3c-e	24.6d	34.5c-f	36.5a	45.3a-c
Hutton	31.6de	19.9de	34.8c-f	—	—
Coker 488	—	—	—	35.0a	41.4bc
C.V.(%)	13.6	9.8	10.9	12.9	10.7

[1] Means within columns followed by the same letter are not significantly different at the .05 probability level according to Duncan's New Multiple Range Test.

Table 22.—Mean yield of soybean varieties on Commerce silt loam at St. Joseph, 1975-79

Maturity group and variety	Year 1975	 1976	 1977	 1978	 1979
	----------	----------	Bushels per acre	----------	----------
Group V					
Dare	50.0ab[1]	36.1h	36.2de	37.7c-f	54.6d-h
Coker 136	48.9ab	46.1d-g	42.9bc	45.1a-c	58.4b-e
Forrest	46.9a-c	42.8e-g	43.9b	49.2a	65.6a
Mack	46.9a-c	47.6c-f	35.9de	37.9c-f	52.5e-h
Hill	41.1c-e	40.7gh	29.7f	37.7c-f	—
Essex	38.8d-f	—	—	—	—
McNair 500	—	43.8d-g	36.7d	43.6a-d	56.2c-h
Deltapine 345	—	—	—	—	53.4e-h
Wilstar 550	—	—	—	—	52.8e-h
Group VI					
Tracy	51.6a	46.1d-g	38.4cd	42.5a-e	53.4e-h
Lancer	51.4a	46.7d-f	47.0ab	42.9a-e	57.6c-h
Hood	47.2a-c	40.6gh	—	—	—
Davis	43.0b-d	48.0cd	42.5bc	39.5c-f	57.8c-g
Lee 68	40.2c-f	46.1d-g	—	—	—
Lee 74	37.9d-f	59.2a	37.0d	44.4a-d	50.1h
Centennial	37.9d-f	41.7fg	37.3d	43.1a-d	56.8c-h
McNair 600	35.6ef	49.3b-d	38.2cd	34.7ef	—
Pickett 71	34.5ef	53.3b	33.4d-f	38.7c-f	50.6f-h
Hood 75	—	40.2gh	50.0a	39.5c-f	55.3d-h
Brysoy 9	—	—	—	36.0d-f	58.2c-f
Tracy-M	—	—	—	—	56.6c-h
Coker 156	—	—	—	—	55.0d-h
Terra-Vig 606	—	—	—	—	50.3gh
Group VII					
McNair 800	49.3ab	46.5d-f	31.2ef	—	—
Bragg	46.1a-c	52.5bc	37.1d	37.0c-f	63.2a-c
Ransom	40.3c-f	58.7a	33.3d-f	36.1d-f	54.6d-f
Semmes	36.6d-f	47.9c-e	—	—	—
Bossier	33.9f	53.3b	—	—	—
Terra-Vig 708	—	—	45.5ab	40.0b-f	61.7a-d
Coker 237	—	—	—	44.8a-c	65.4ab
Agripro AP 70	—	—	—	38.5c-f	56.4c-h
McNair 710	—	—	—	33.5f	51.4e-h
Wilstar 790	—	—	—	32.7f	53.4e-h
Group VIII					
Coker 338	45.9a-c	60.7a	33.2d-f	47.9ab	58.7a-e
Coker 488	—	—	—	44.5a-d	61.9a-d
C.V.(%)	9.9	14.0	8.2	12.1	7.8

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[1] Means within columns followed by the same letter are not significantly different at the .05 probability level according to Duncan's New Multiple Range Test.

Table 23.—Mean yield of soybean varieties on Sharkey clay at St. Joseph, 1975-79

Maturity group and variety	Year 1975	1976	1977	1978	1979
	Bushels per acre				
Group V					
Farrest	41.9de[1]	15.7j	32.0k	31.7g-k	47.0e-i
Mack	38.3ef	16.8j	31.1b-d	29.6i-k	44.9hi
Essex	33.6fg	—	—	—	—
Dare	33.2fg	16.7j	30.6cd	30.2h-k	44.3i
Caker 136	32.3fg	17.5ij	32.5bc	28.9jk	37.2j
Hill	30.3g	24.6e-i	22.3d	25.0k	—
McNair 500	—	23.2f-j	37.5a-c	36.5c-i	47.2d-i
Deltapine 345	—	—	—	—	50.7a-g
Wilstar 550	—	—	—	—	45.7g-i
Group VI					
Davis	55.7a	36.2a-c	44.9a	39.3a-f	51.8a-f
Lee 68	53.7ab	32.8a-d	—	—	—
McNair 600	50.1a-c	30.0b-g	41.0ab	36.1c-i	—
Pickett 71	49.4a-d	32.9a-d	39.0a-c	46.2a	51.2a-g
Centennial	48.3a-d	33.9a-c	39.4a-c	42.5a-c	53.2a-c
Haod	47.6b-d	18.4h-j	—	—	—
Lee 74	47.4b-d	31.2a-e	39.4a-c	38.5b-g	51.4a-g
Lancer	44.8c-e	22.3g-j	34.3bc	37.3c-h	46.6f-i
Tracy	—	35.0a-c	38.2a-c	45.6ab	52.5a-e
Haad 75	—	20.8h-j	35.8a-c	34.6d-j	50.4b-h
Brysay 9	—	—	—	38.3b-g	48.8c-i
Caker 156	—	—	—	—	55.8ab
Terra-Vig 606	—	—	—	—	54.2a-c
Tracy-M	—	—	—	—	51.6a-f
Graup VII					
McNair 800	51.2a-c	25.8d-h	32.9bc	—	—
Bragg	49.2a-d	38.9a	33.4bc	41.4a-d	52.9a-d
Bassier	47.7b-d	30.5b-f	40.9ab	—	—
Ransam	43.8c-e	29.0b-g	31.3b-d	32.5f-j	44.2i
Semmes	—	33.2a-d	35.7a-c	—	—
Terra-Vig 708	—	—	39.9a-c	39.3a-f	53.3a-c
Agripra AP 70	—	—	—	41.6a-d	53.0a-d
Caker 237	—	—	—	41.0a-e	56.4a
Wilstar 790	—	—	—	39.6a-f	49.5c-i
McNair 710	—	—	—	33.7e-j	48.3c-i
Graup VIII					
Coker 338	55.6a	37.0ab	32.5bc	35.6c-j	49.5c-i
Huttan	—	32.4a-e	32.5bc	—	—
Cabb	—	28.7c-g	30.2cd	—	—
Caker 488	—	—	—	30.3h-k	50.5b-h
C.V.(%)	10.1	17.3	17.0	12.2	6.9

[1] Means within columns fallawed by the same letter are nat significantly different at the .05 prababili ty level according to Duncan's New Multiple Range Test.

Table 24.—Mean yield of soybean varieties at Winnsboro, 1975-79

Maturity group and variety	Year				
	1975	1976	1977	1978	1979
	Bushels per acre				
Group V					
Forrest	33.7a-c[1]	19.6a	33.4a-c	11.0ab	34.5a-e
Hill	33.3a-c	13.8a	35.1a	13.4ab	—
Mack	32.6a-c	20.5a	34.7ab	12.2ab	28.7g
Dare	28.0dc	17.0a	28.6a-e	12.1ab	30.2d-g
Essex	27.8bc	—	—	—	—
Coker 136	25.6c	17.2a	26.4a-e	8.5b	30.8c-g
McNair 500	—	15.2a	31.3a-d	10.2ab	31.1c-g
Deltapine 345	—	—	—	—	35.2a-d
Wilstar 550	—	—	—	—	29.7e-g
Group VI					
Centennial	39.4a	13.5a	21.9de	14.4ab	32.8b-g
Lancer	38.7a	16.5a	29.5a-e	12.2ab	31.4b-g
Tracy	37.9ab	17.0a	24.7b-e	12.2ab	36.6ab
Pickett 71	36.0ab	18.9a	26.1a-e	10.4ab	31.6b-g
McNair 600	35.3a-c	21.3a	27.3a-e	16.7a	—
Lee 68	35.2a-c	17.5a	—	—	—
Curtis	34.7a-c	—	—	—	—
Lee 74	32.8a-c	17.9a	26.1a-e	12.8ab	28.8fg
Hood	30.8a-c	15.7a	—	—	—
Davis	29.4a-c	19.8a	29.6a-e	9.5b	34.6a-e
Hood 75	—	20.9a	27.3a-e	11.8ab	34.3a-e
Brysoy 9	—	—	—	9.3b	32.8b-g
Coker 156	—	—	—	—	34.8a-e
Group VII					
Bossier	35.2a-c	16.8a	26.8a-e	—	—
Ransom	34.2a-c	20.9a	29.4a-e	10.4ab	36.8ab
McNair 800	30.6a-c	19.6a	24.2c-e	—	—
Bragg	29.6a-c	14.6a	20.6e	10.5ab	34.9a-e
Semmes	29.3a-c	17.4a	20.2e	—	—
Terra-Vig 708	—	—	29.5a-e	9.1b	36.0a-c
Wilstar 790	—	—	—	10.7ab	35.4a-d
McNair 710	—	—	—	9.1b	33.4b-g
Coker 237	—	—	—	8.4b	39.0e
Agripro AP 70	—	—	—	8.4b	34.6a-e
Group VIII					
Hutton	33.9a-c	16.1a	19.4e	—	—
Coker 338	25.6c	15.7a	23.7c-e	9.1b	33.7a-g
Cobb	—	17.3a	23.6c-e	—	—
Coker 488	—	—	—	8.4b	34.1a-g
C.V.(%)	15.6	31.2	21.9	35.5	13.2

[1] Means within columns followed by the same letter are not significantly different at the .05 probability level according to Duncan's New Multiple Range Test.

Summary

Variety trials are conducted to provide data on the relative performance of soybean varieties when grown in the various soil and climatic regions of the state. Since no variety has all of the desirable traits for all situations, producers must select varieties best adapted to their specific needs. In addition to yield, factors which should be considered during variety selection include reaction to the common disease and nematode pests, lodging, shattering, height of lower pods, and maturity date. Each of the 14 varieties tested during all 5 years of the study is recommended for production throughout Louisiana. These varieties have resistance to the common foliar diseases and several have resistance to one or more species of nematode present in the state.

Mack and Pickett 71 have resistance to race 3 of the cyst nematode *(Heterodera glycines),* Lee 74 and Bragg are resistant to the common species of root-knot nematode *(Meloidogyne incognita),* and Dare and Bragg have moderate resistance to the reniform nematode *(Rotylenchulus reniformis).* Both Forrest and Centennial have a high level of resistance to all three nematode species.

Most of the varieties have a moderate to high level of resistance of phytophthora rot *(Phytophthora megasperma);* however, Coker 136 and Coker 338 are susceptible and Ransom is highly susceptible to the organism.

Davis, Lancer, and Bragg set their lowest pods 5 to 7 inches above the soil and are recommended for planting in newly cleared ground.

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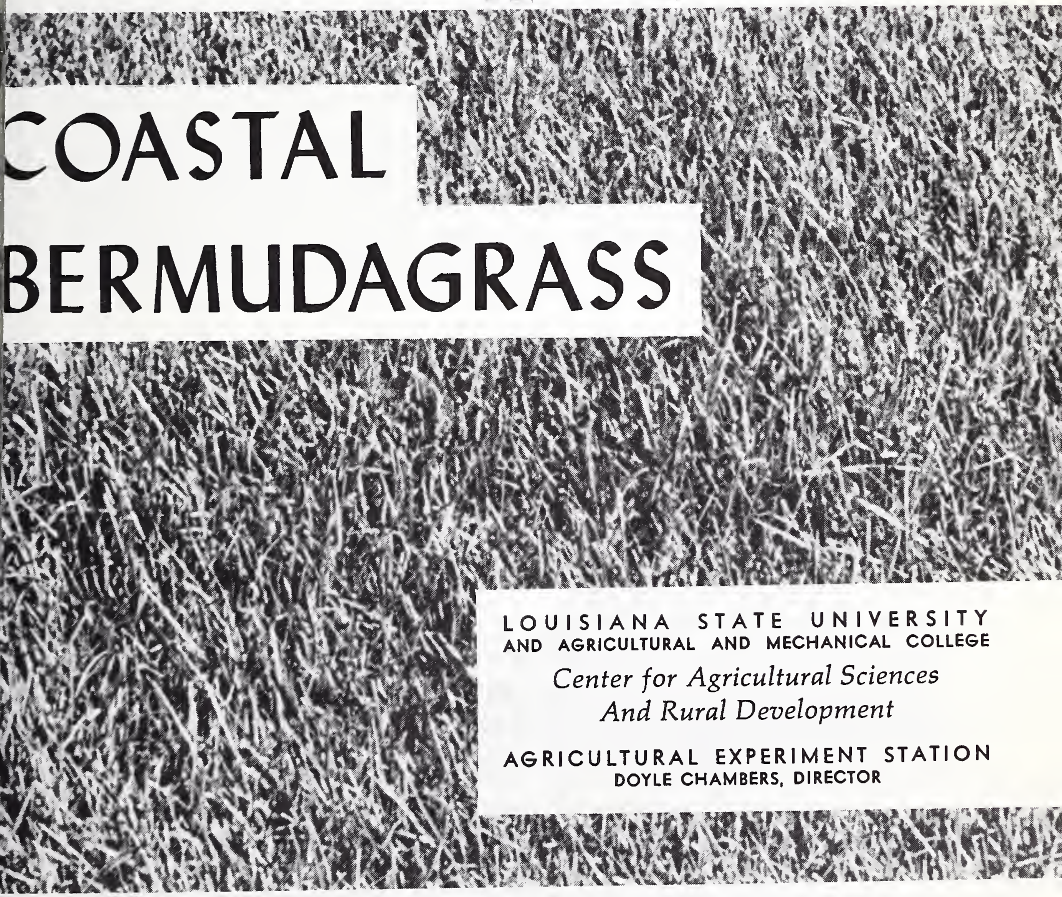
Effects of Harvest Date and Age On Quality of

LSU
SEP 30 1980

COASTAL BERMUDAGRASS



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The Louisiana Agricultural Experiment Station follows a nondiscriminatory policy in programs and employment.

Effects of Harvest Date and Age on Quality of Coastal Bermudagrass

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Introduction

The cost of producing feed for livestock in the form of forage has been estimated to be about one-third that of producing equivalent amounts of grain; hence, greater emphasis is being placed on production practices and nutritive components affecting forage quality. In addition, studies of management practices which affect forage quality need to be conducted.

Numerous data are available that show the effects of forage age on quality, but very limited data are available on the effects of harvest date on quality. The study reported here was conducted to determine the effects of harvest date—June through October—as well as the effect of age—4, 6, and 8 weeks—on quality of Coastal bermudagrass.

Review of Literature

Few, if any, southern forage crops equal Coastal bermudagrass in excellence of agronomic characteristics. Studies by King et al. *(6),*[3] Brooks et al. *(2)*, Clifton et al. *(3)*, and Nelson et al. *(9)* have shown, however, that milk production was lowered beyond the expected persistency curve when lactating cows were fed Coastal bermudagrass as their principal roughage.

Research data amassed by Lowery et al. *(7)* demonstrated that crude protein content decreased and fibrous components increased in Coastal bermudagrass forage with increasing age at harvest. Forage dry matter digestibility decreased with age of cut, and milk production of lactating cows was reduced when consuming hay of less frequent harvest.

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[3] Italic numbers in parentheses refer to Literature Cited, page 23.

Experimental Procedure

Coastal bermudagrass forage was harvested at three different forage ages on five different dates in 1971 at the North Louisiana Hill Farm Experiment Station, Homer. A total of 15 hays resulted from this management schedule. The harvests were made from three fields of Coastal bermudagrass that had been established in 1967 and uniformly fertilized and managed since then. Each field was assigned either a 4-, 6-, or 8-week harvest schedule.

The herbicide Princep was applied to the entire experimental area in early December, 1970. Dolomitic limestone was applied at the rate of 2 tons per acre on March 10. Phosphorus and potassium were applied in late March according to need as indicated by results of soil analyses. All forage was cut and removed on April 19, 1971 to establish a uniform starting date of growth for all future hay harvests. Additional clean-off cuttings were made as required on respective fields that provided hay for the 6- and 8-week ages in order to obtain hay of all three ages harvested on the same date (Figure 1). Nitrogen was uniformly applied to all fields at the rate of 100 pounds per acre on April 20, May 21, June 18, July 15, August 17, and September 10, 1971, thus supplying a total of 600 pounds of applied nitrogen per acre to each field, irrespective of age of forage at cutting or date of harvest. The forages were harvested June 14, July 12, August 9, September 7, and October 4, 1971.

Field-curing conditions were considered good for all cuttings of hay, except the harvest made in August. The average field-curing time was 4

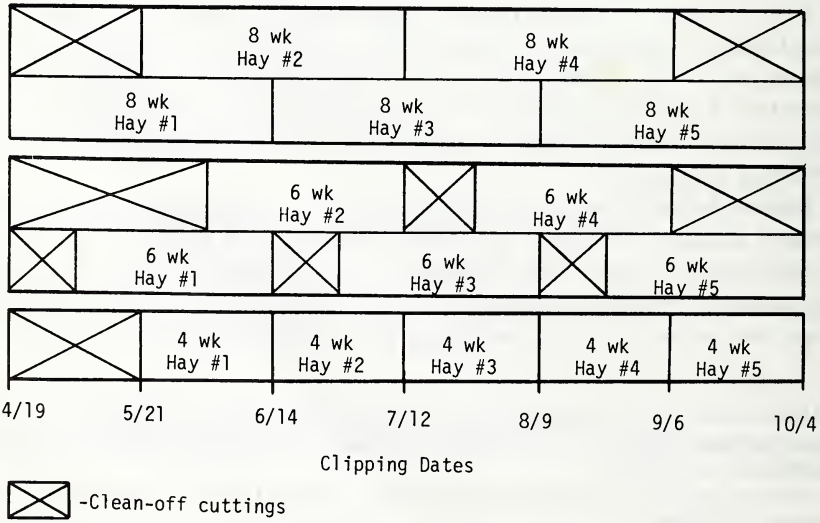

Figure 1.—Coastal bermudagrass clipping schedule.

days. The 4-week hay, which was harvested in August, received 0.59 inch of rainfall the day after it was cut but was dry enough to bale the fourth day after cutting. The 6- and 8-week hays had not dried sufficiently by the fourth day and received an additional 1.09 inches of rain on the fifth day, for a total of 1.68 inches before being baled. There were 7 days between cutting and baling of these 6- and 8-week hays.

All forage quality determinations were made at the Southeast Louisiana Dairy and Pasture Experiment Station, Franklinton. These measurements included laboratory chemical and in vitro digestible dry matter analyses (IVDDM). In vivo digestible dry matter was determined in conventional digestion trials using wethers. Voluntary intake and average daily gain (ADG) were determined with beef steers.

The digestion trials were conducted utilizing 9-day preliminary and 5-day total fecal collection periods. One wether was assigned to each of the 15 hays. This digestion procedure was repeated six times to obtain a total of six sheep digestion values per hay. The hay fed to the wethers during the digestion trial was randomly selected from the same lots of hay that were fed to the steers. All hays were chopped to approximately one-half inch length with a hammer mill before feeding. Wethers were fed twice daily and were limited to 85.0 percent of *ad libitum* intake to minimize refusals. Fresh water and plain salt were available to the wethers *ad libitum*. Each hay was sampled daily before feeding during the 5-day total collection period, and the individual daily samples from each hay were composited for chemical analyses. The forage and total fecal samples were dried in a forced air oven at 50°C. After drying, the forage and fecal materials were ground through a 1 mm screen, and then stored in air-tight containers for chemical analyses.

Crude protein (CP) content was determined by the Kjeldahl method, as outlined in A.O.A.C. *(1)*. Cell wall constituents (CWC), acid detergent fiber (ADF), cellulose, and acid-insoluble lignin (AIL) were assayed by methods outlined in USDA Agricultural Handbook #379 *(5)*. Hemicellulose was calculated as the difference between CWC and ADF. The IVDDM values were determined by the modified Van Soest procedure *(10)*.

Voluntary intake and ADG were determined using 90 grade Hereford steers weighing approximately 450 pounds each. Steers were treated for internal parasites and dehorned. Prior to the feeding trial, animals were put on a 60-day standardization period and fed ryegrass hay *ad libitum,* plus 2.2 pounds of a high-energy 18.0 percent crude protein feed daily. The ADG for all animals averaged 0.75 pound during the standardization period.

The steer feeding trial was a 3 x 5 factorial design, beginning December 7, 1972 and continuing for 90 days. Animals were grouped by weight into six blocks of 15 steers each, with one steer per block assigned to each of the 15 hays. The average weight of the steers at the beginning of the experimental period was 475 pounds. The steer weights among the six blocks ranged from 425 to 530 pounds.

One animal from each of two blocks was assigned to each of the 15 hays. To obtain individual intake values, these 30 animals were maintained in a tie-stanchion barn and fed their assigned hay individually. Animals in the remaining four blocks were group-fed test hays in drylot. One animal in each block was assigned to each of the 15 hays, resulting in four animals group-fed on each hay. The per-animal daily hay intake values for each four-steer group were averaged and used as a third value, along with the two individual intake values per hay obtained from the stanchioned animals for statistical analyses. Daily intake, expressed as a percentage of bodyweight, was calculated from an average of the initial and final body weights. Animals were fed 10 percent in excess of their *ad libitum* intake, with refusals collected once daily.

The data were subjected to analysis of variance; Duncan's Multiple Range Test *(4)* was used to determine mean differences. Correlation coefficients were calculated to express relationships among chemical composition and animal performance values.

Results and Discussion

Chemical compositions of all hays are shown in Table 1. Even though differences ($P<.05$) were found in the fibrous constituents (CWC, ADF, cellulose, hemicellulose, and AIL) among harvest dates within each age of forage, no trend was shown in the fibrous components with advancing season (Figures 2 to 6).

The effects of rain on hay composition are evidenced in data from the August 9 harvest of 6- and 8-week hays, on which 1.68 inches of rain had fallen between cutting and baling. These rained-on hays tended to be higher in ADF and cellulose than hays of the same age harvested on other dates. Hemicellulose values of the rained-on hays were among the lowest.

Within the 4- and 8-week hays, very small, mostly non-significant, differences were found in percent CP (Figure 7). In all cases CP tended to be lowest in forages harvested on June 14, contrary to reports that protein content usually is highest in forage harvested early in the growing season *(11)*. Within the 4-week hays, that forage harvested in June was approximately 2.0 percentage units lower in CP than forages harvested in July, August, and September. Content of CP in 6-week hays harvested in June and August was lower ($P<.05$) than that in hays of the same age harvested at other dates. The 8-week forage harvested in June was significantly lower ($P<.05$) in CP content than forage of equal age harvested in October.

Table 1.—Effects of age and harvest date on chemical composition of Coastal bermudagrass hay

Hay age and harvest date	CWC[1]	ADF[2]	Cellulose	AIL[3]	Hemicellulose	CP[4]
			-Percent[5]-			
4-week hay						
June 14	78.7^{c-e}	38.6^{b}	32.8^{b-e}	5.00^{a-c}	40.1^{ab}	13.6^{b}
July 12	75.0^{ab}	35.1^{a}	30.0^{a}	4.12^{a}	39.9^{ab}	15.4^{a}
Aug 9	74.5^{a}	38.7^{b}	32.4^{bc}	4.85^{ab}	35.8^{cd}	15.9^{a}
Sept 6	79.8^{de}	38.7^{b}	32.5^{b-d}	4.72^{ab}	41.0^{a}	15.8^{a}
Oct 4	77.1^{a-d}	39.5^{bc}	32.5^{b-d}	6.42^{c-e}	38.1^{a-d}	14.6^{ab}
6-week hay						
June 14	78.4^{c-e}	39.6^{bc}	33.5^{b-e}	5.55^{b-d}	38.8^{a-c}	10.1^{d}
July 12	76.1^{a-c}	39.9^{b-d}	33.3^{b-e}	6.03^{b-e}	36.2^{b-d}	13.4^{b}
Aug 9	80.8^{e}	44.3^{ef}	36.6^{f}	6.91^{de}	36.5^{b-d}	11.5^{cd}
Sept 6	80.2^{de}	42.4^{c-f}	34.4^{c-f}	6.40^{c-e}	38.4^{a-d}	13.4^{b}
Oct 4	77.8^{b-e}	41.8^{c-f}	34.1^{c-e}	6.39^{c-e}	36.0^{cd}	13.5^{b}
8-week hay						
June 14	78.2^{c-e}	40.4^{b-d}	33.7^{b-e}	6.05^{b-e}	37.8^{a-d}	10.1^{d}
July 12	78.7^{c-e}	41.2^{b-e}	34.2^{c-e}	6.14^{b-e}	37.1^{a-d}	10.9^{cd}
Aug 9	80.1^{de}	45.0^{f}	36.6^{f}	7.38^{e}	35.3^{cd}	11.3^{cd}
Sept 6	80.9^{e}	43.0^{d-f}	34.6^{d-f}	6.91^{de}	37.8^{a-d}	10.8^{cd}
Oct 4	79.4^{de}	44.4^{ef}	34.9^{ef}	7.34^{e}	35.0^{d}	11.7^{c}
C.V.[6]	1.11	1.45	1.37	5.44	1.99	8.65
s.e.[7]	1.06	.97	.67	.50	1.24	.45

[1] [2] [3] [4] Cell wall constituents, acid detergent fiber, acid-insoluble lignin, and crude protein, respectively.

[5] Means in the same sub-column with different superscripts are significantly different ($P<.05$).

[6] Coefficient of variation, percent. [7] Standard error of treatment means.

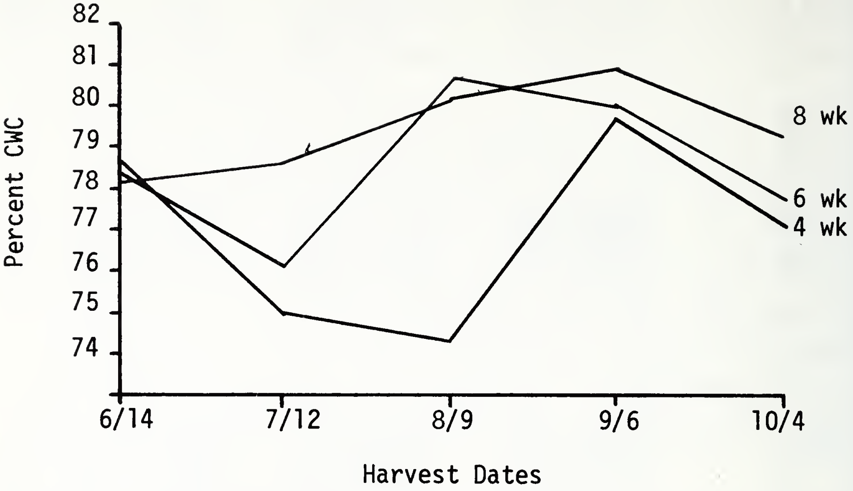

Figure 2.—Percentage cell-wall constituents by age of hay and date of harvest.

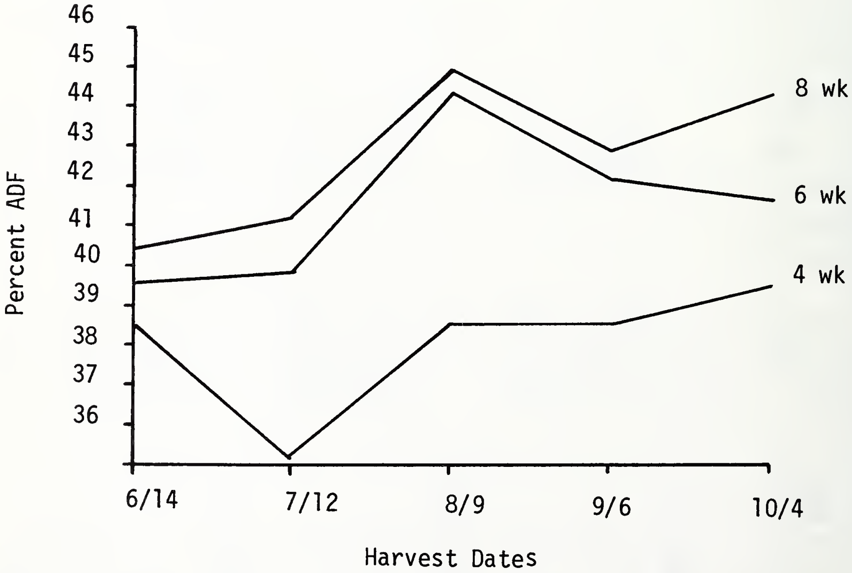

Figure 3.—Percentage acid detergent fiber by age of hay and date of harvest.

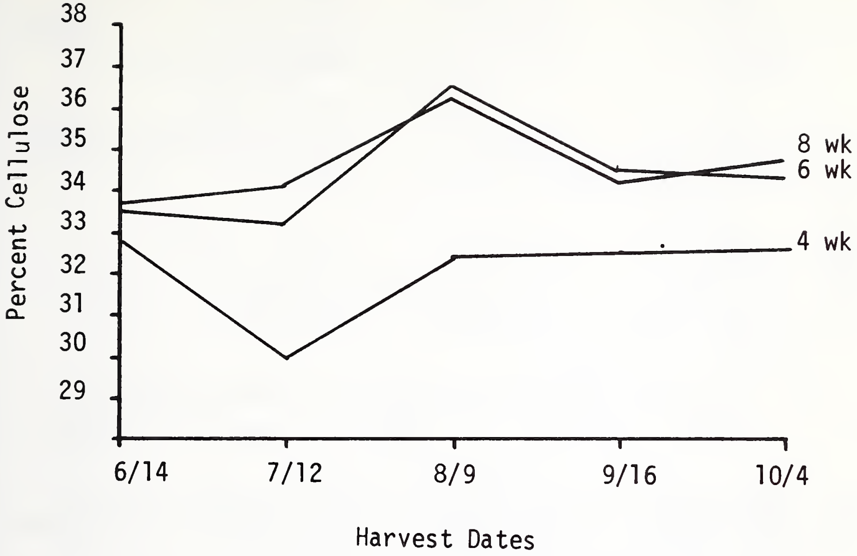

Figure 4.—Percentage cellulose by age of hay and date of harvest.

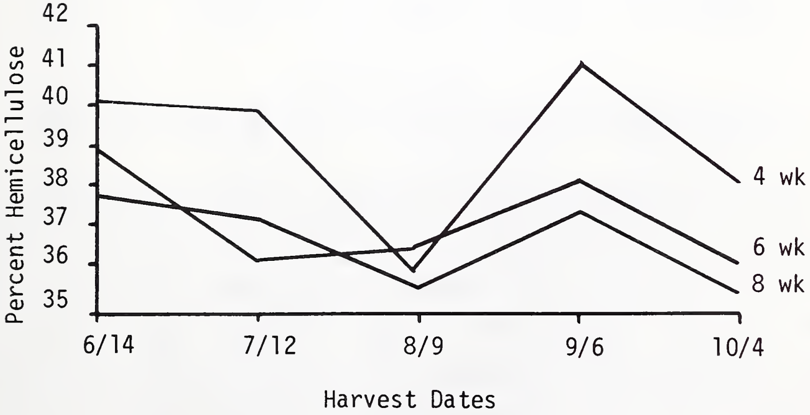

Figure 5.—Percentage hemicellulose by age of hay and date of harvest.

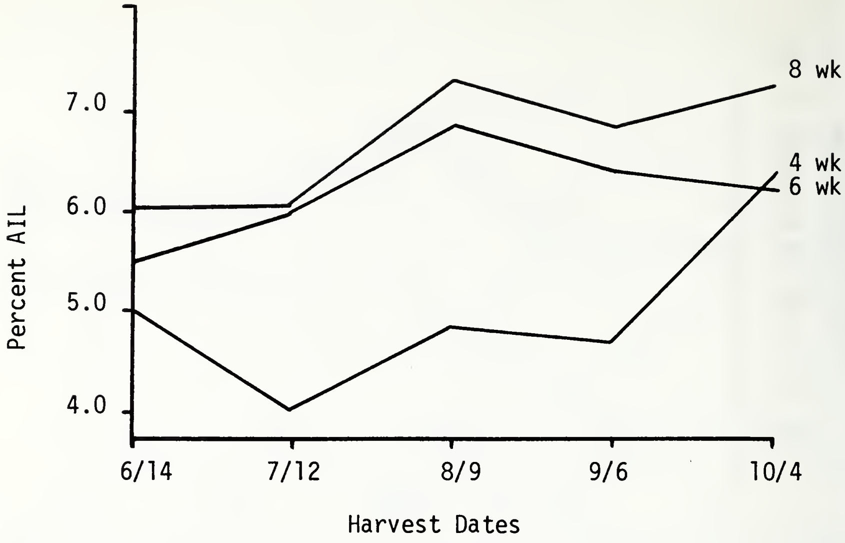

Figure 6.—Percentage acid-insoluble lignin by age of hay and date of harvest.

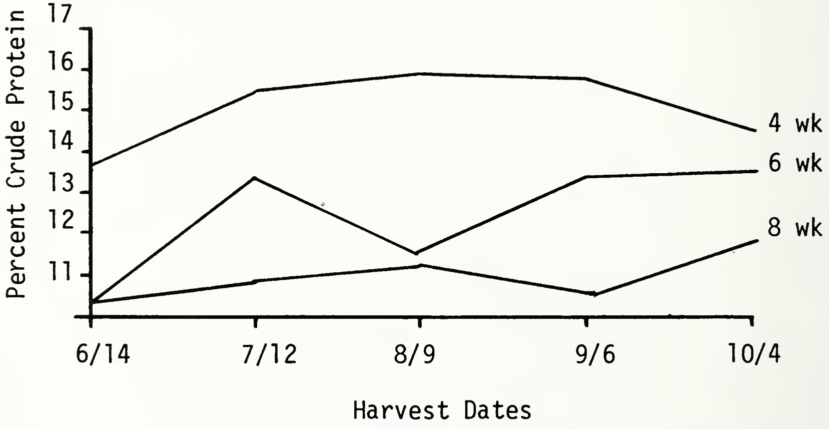

Figure 7.—Percentage crude protein by age of hay and date of harvest.

The effects of date and age of forage at harvest on digestibility of components are shown in Table 2. No significant differences were found in digestibility values of the fibrous constituents of the 4-week hays which were harvested in June, July, August, and September, but most were at least 10 percentage units higher ($P < .05$) in digestibility than the October-cut, 4-week hay (Figures 8 to 11). Also, digestible dry matter of the October-harvested hay was from 6 to 11 percentage units lower than that of the other 4-week hays. Dry matter digestibility tended to decline as season advanced in all hay-age groups (Figure 12). However, digestibility of

Table 2.—Effects of age and harvest date on digestibility of Coastal bermudagrass hay

Hay age and harvest date	CWC	ADF	Cellulose	Hemicellulose	CP	DDM	IVDDM
	- - - - - - - - - - - - - - - -	- -	- Digestion coefficient,	percent[1]- - -	- - - - -	- - -	- - -
4-week hay							
June 14	61.0^{a}	58.1^{a}	66.3^{a}	63.1^{ab}	63.1^{cd}	54.6^{ab}	64.9^{a-c}
July 12	61.2^{a}	56.0^{ab}	64.6^{a-c}	63.2^{a}	6[illegible]$.5^{a}$	56.9^{a}	67.1^{a}
Aug 9	58.0^{ab}	54.5^{a-c}	63.6^{a-d}	61.1^{a-c}	62.4^{c-e}	52.0^{b-d}	65.9^{ab}
Sept 6	61.0^{a}	55.4^{ab}	65.4^{ab}	65.4^{a}	66.6^{ab}	52.7^{bc}	64.5^{a-c}
Oct 4	51.1^{e}	45.3^{g}	56.4^{f-h}	58.0^{cd}	61.3^{c-f}	45.8^{fg}	58.0^{d-g}
6-week hay							
June 14	55.9^{bc}	53.1^{b-e}	61.2^{c-e}	58.4^{b-d}	57.1^{gh}	51.6^{b-d}	61.3^{b-e}
July 12	54.6^{b-d}	51.7^{c-e}	60.8^{de}	57.5^{cd}	66.6^{ab}	50.7^{cd}	62.3^{a-d}
Aug 9	51.8^{de}	50.9^{de}	59.3^{ef}	52.8^{e-g}	58.5^{f-h}	46.9^{ef}	56.4^{e-h}
Sept 6	55.6^{bc}	53.3^{b-d}	60.9^{c-e}	58.4^{b-d}	61.9^{c-e}	49.4^{c-e}	58.9^{d-f}
Oct 4	53.1^{c-e}	51.1^{c-e}	59.5^{ef}	55.4^{d-f}	61.1^{c-f}	48.4^{d-f}	58.2^{d-f}
8-week hay							
June 14	54.7^{b-d}	54.1^{b-d}	62.1^{b-e}	58.7^{b-d}	59.6^{e-g}	52.2^{bc}	59.9^{cf}
July 12	54.7^{b-d}	53.2^{b-d}	60.8^{de}	55.7^{d-f}	63.6^{bc}	51.2^{b-d}	57.9^{dg}
Aug 9	50.1^{ef}	49.7^{ef}	57.2^{fg}	51.1^{g}	60.4^{d-f}	45.9^{fg}	53.6^{gh}
Sept 6	51.5^{de}	46.6^{fg}	55.5^{gh}	57.0^{c-e}	59.5^{e-h}	46.8^{ef}	55.9^{f-h}
Oct 4	47.8^{f}	45.1^{g}	53.5^{h}	51.7^{fg}	56.9^{h}	43.6^{g}	52.3^{h}
C.V.[2]	4.80	5.22	4.65	6.20	3.69	5.52	1.20
s.e.[3]	1.04	1.11	1.15	1.47	.93	1.13	1.55

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[1] Means in the same sub-column with different superscripts are significantly different ($P<.05$).

[2] Coefficient of variation, percent. [3] Standard error of treatment means.

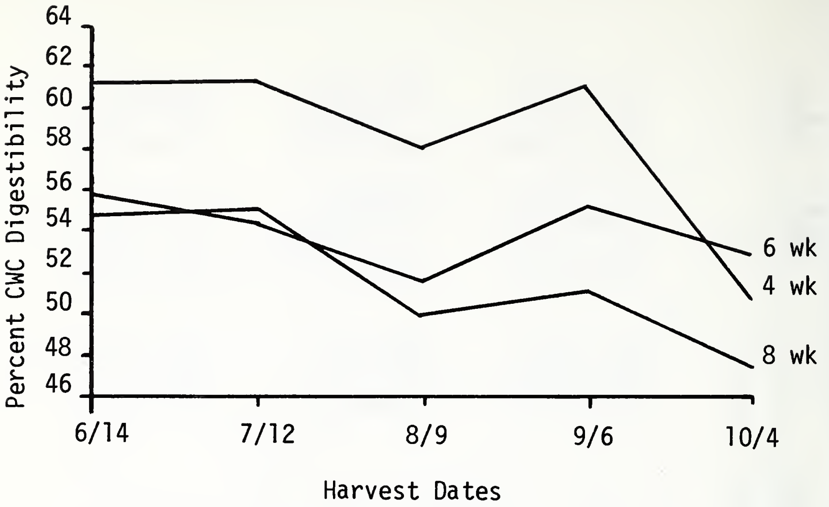

Figure 8.—Percentage of digestible cell-wall constituents by age of hay and date of harvest.

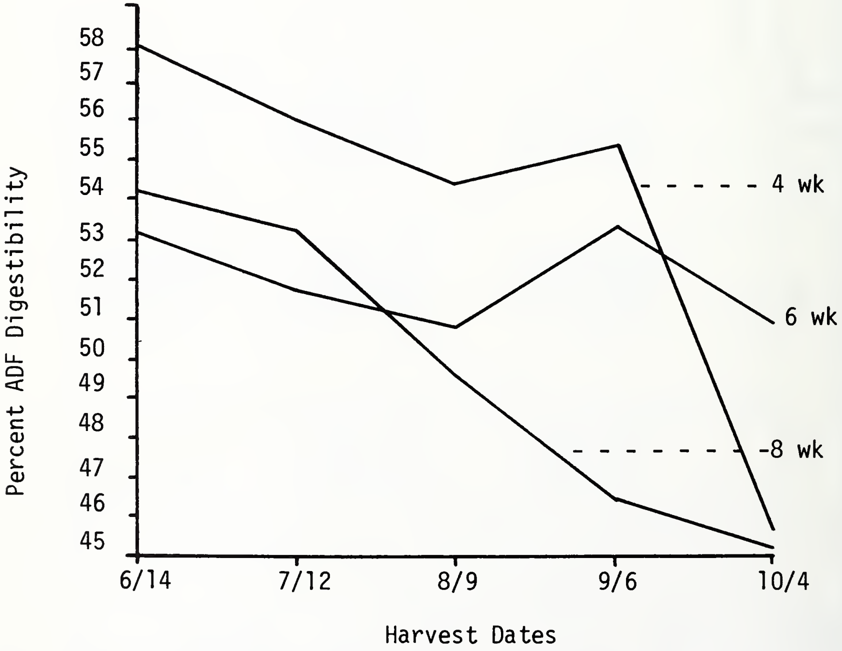

Figure 9.—Percentage digestible acid detergent fiber by age of hay and date of harvest.

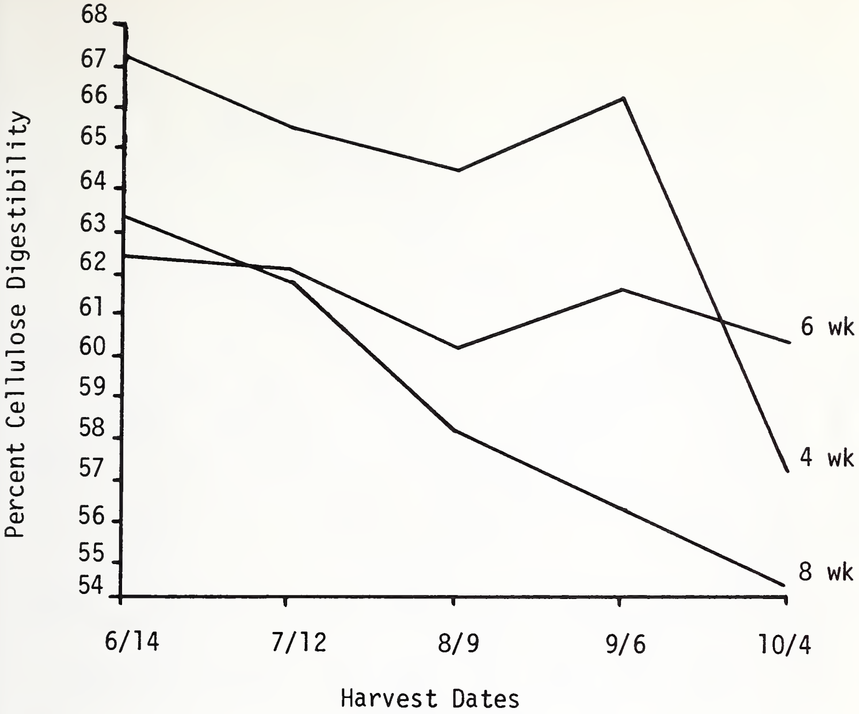

Figure 10.—Percentage digestible cellulose by age of hay and date of harvest.

6-week hays did not appear to be affected by date of harvest to the extent that it was in 4- and 8-week hays. Ranges in DDM coefficients for the 4-, 6-, and 8-week hays were 56.9 to 45.8, 51.6 to 48.4, and 52.2 to 43.6, respectively.

Digestibility of crude protein was not consistent among hays (Figure 13). Within the group of 4-week hays, CP digestibility was significantly ($P < .05$) higher in the July and September cuts. The 6- and 8-week hays were highest in CP digestibility at the July harvest.

Harvest date means, averaged over forage age, for chemical composition and digestibility of the forages are shown in Table 3. Differences ($P < .05$) were found in CWC content and digestibility among hays harvested on different dates, but no linear season effect was shown. Forage ADF content was highest ($P < .05$) after midseason, but ADF digestibility was very erratic. Cellulose content differed little during the season; however, cellulose digestibility was lowest ($P < .05$) at the October 4 harvest. As the season advanced, forage AIL content tended to increase. Forage hemicellulose content and digestibility were lower ($P < .05$) in October than in June. Both content and digestibility of forage CP varied, with

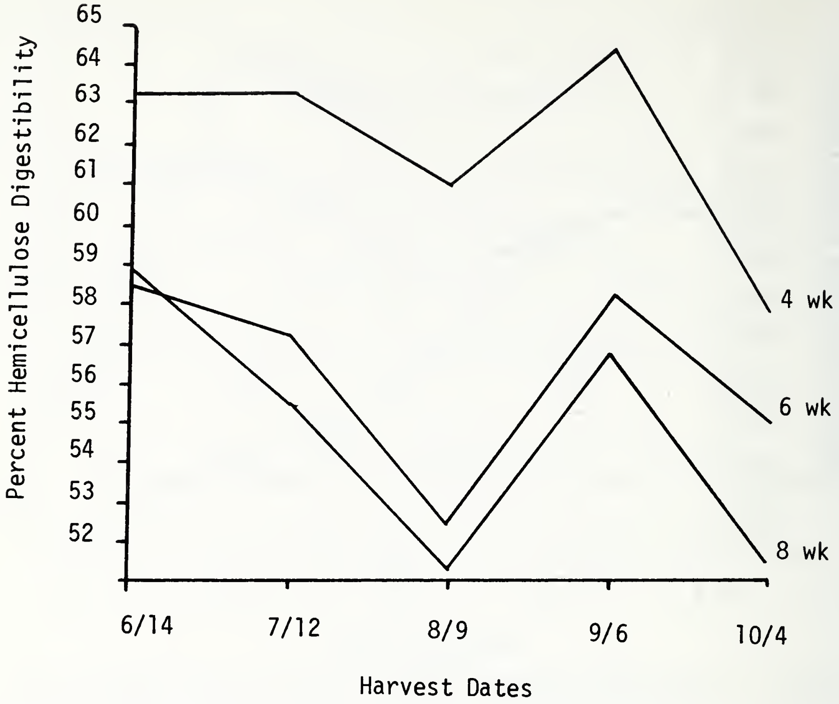

Figure 11.—Percentage digestible hemicellulose by age of hay and date of harvest.

content being lowest ($P<.05$) in June and digestibility being highest ($P<.05$) in the July-cut hay. Digestible dry matter values (DDM) tended to decline as the season advanced, with the October-cut hay being lower ($P<.05$) than that harvested in June and July. Laboratory digestion values (IVDDM) showed that hays harvested in August and October were inferior to hays from the other three harvest dates.

Means for composition and digestibility of forages by forage age, as an average of dates, are reported in Table 4. Both forage composition and component digestibility were affected by age at harvest. Six- and 8-week hays did not differ significantly in content of CWC, ADF, cellulose, or AIL. These constituents were lowest ($P<.05$) in forage 4-weeks of age. Each increase in age of cut resulted in a significant ($P<.05$) reduction in forage CP content. Digestibility of all components, except CP, dropped ($P<.05$) as age of forage increased by 2-week increments. Crude protein digestibility decreased ($P<.05$) when age of forage increased from 4 to 6 weeks, but delaying harvest another 2 weeks did not significantly ($P<.05$) alter CP digestibility. It is evident that Coastal bermuda forage cut at 4 weeks of age was superior in quality to that harvested at 6 and 8 weeks. Forage age at time of harvest affected quality more than season of harvest.

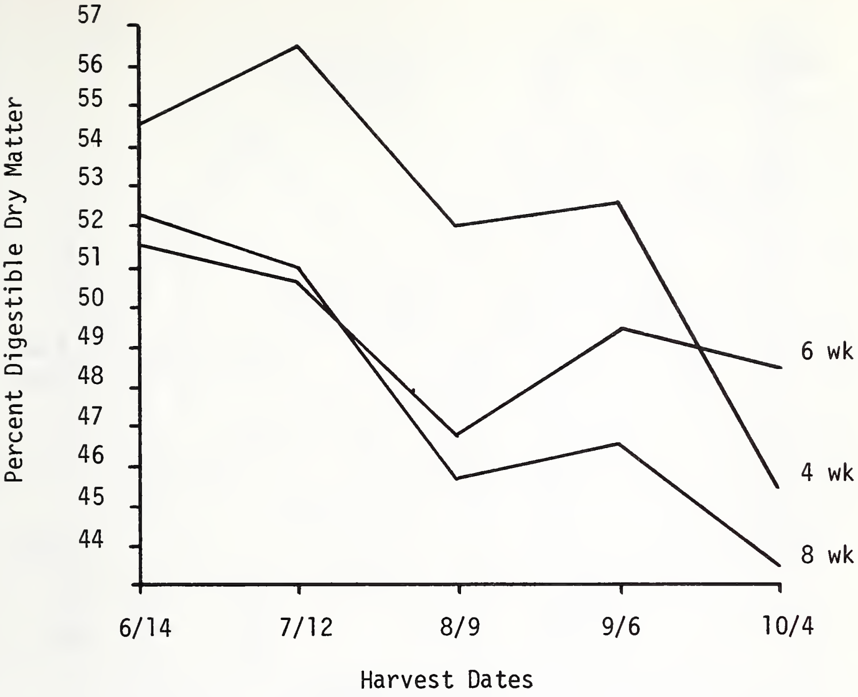

Figure 12.—Percentage digestible dry matter by age of hay and date of harvest.

Fibrous components tended to increase in older forage, with a corresponding decrease in digestibility. Dry matter digestibility decreased with increases in age of forage at harvest.

Data on the daily intake and body weight gain (ADG) of steers fed the different hays are presented in Table 5. Animal intake was not influenced by date of harvest, as an average of all ages. Mean values, expressed as a percentage of body weight, ranged from 2.05 for the August harvest to 2.40 for the June cut. Intakes of 4- and 6-week hays were greater ($P<.05$) than that of 8-week hays when averaged across all cutting dates.

Hays harvested in June, July, and September produced higher ($P<.05$) ADG than hays cut in August and October (Table 5). The ADG values resulting from feeding the June, July, and September hays were significantly greater than those of the August and October hays, neither of which produced acceptable gains. Mean ADG values for hays were reduced significantly with each 2-week delay in cut. The ADG was small in magnitude for the 4- and 6-week hays. The steers consuming the 8-week hay harvested in August and October lost weight during the study. Except for the effect of rain on the August-cut hay, it appears that there was no

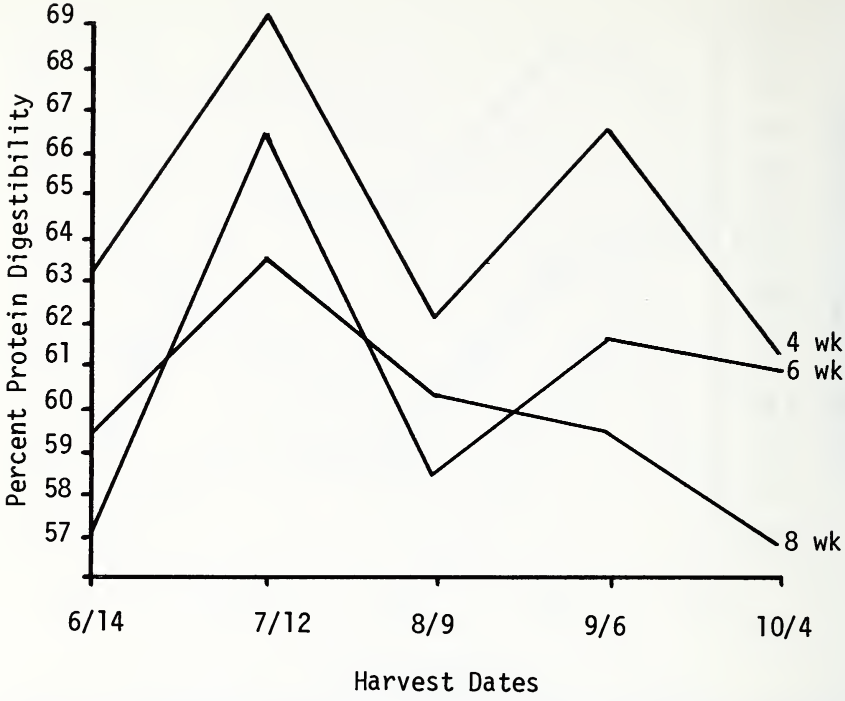

Figure 13.—Percentage digestible protein by age of hay and date of harvest.

seasonal effect on quality of the hay, as measured by animal performance, until October. There was a significant ($P<.05$) linear decrease in ADG of steers as age of forage consumed increased.

Coefficients of variation (CV) revealed intake and ADG were 15.0 and 98.0 percent, respectively. These values are extremely high when compared with results of similar studies previously conducted at this station. Typical CV percentages for intake and ADG measurements in earlier studies have ranged from 3 to 4, and from 45 to 55, respectively. The high CV values found in the present study probably resulted from combining data gathered on two blocks of steers kept in a tie-stanchion barn with that of four other blocks of group-fed steers. It is suspected that confinement of steers kept in the tie-stanchion barn limited exercise and competition and prevented the animals from performing normally. Intake and ADG were lower for all confined animals compared with the group-fed steers, and considerable variation was found between the two steers in each pair.

A primary objective of subjecting forages to laboratory analyses is to develop procedures for predicting animal performance without having to use the animal in feeding trials. The relationships among laboratory values and animal performance were measured in this study by correlation

Table 3.—Mean effects of harvest date on composition and digestibility of Coastal bermudagrass hay

	Composition (averaged over forage ages)[1]					
Harvest date	CWC	ADF	Cellulose	AIL	Hemicellulose	CP
	percent					
June 14	78.4^{bc}	39.5^{b}	33.3^{ab}	5.53^{ab}	38.9^{a}	11.2^{c}
July 12	76.6^{a}	38.7^{a}	32.5^{a}	5.43^{a}	37.7^{ab}	13.3^{a}
Aug 9	78.4^{bc}	42.6^{c}	35.2^{c}	6.38^{bc}	35.9^{b}	12.9^{b}
Sept 6	80.3^{c}	41.4^{c}	33.8^{b}	6.01^{abc}	39.1^{a}	13.3^{a}
Oct 4	78.1^{ab}	41.9^{c}	33.7^{b}	6.72^{c}	36.4^{b}	13.3^{a}

	Digestibility (averaged over forage ages)[2]						
Harvest date	CWC	ADF	Cellulose	Hemicellulose	CP	DDM	IVDDM
	Digestion coefficient, percent						
June 14	57.2^{a}	60.1^{a}	55.1^{a}	63.2^{a}	59.9^{c}	52.5^{a}	61.4^{a}
July 12	56.8^{a}	58.8^{ab}	53.6^{ab}	62.1^{a}	66.6^{a}	53.3^{a}	60.9^{a}
Aug 9	53.3^{b}	55.0^{b}	51.7^{c}	60.0^{b}	60.4^{c}	48.1^{b}	56.5^{b}
Sept 6	56.0^{a}	60.3^{a}	51.8^{bc}	60.6^{a}	62.6^{b}	50.1^{b}	59.3^{a}
Oct 4	50.7^{c}	55.0^{b}	47.2^{d}	56.4^{b}	59.7^{c}	45.9^{c}	55.7^{b}

[1] [2]Means in the same sub-column with different superscripts are significantly different ($P<.05$).

Table 4.—Mean effects of forage age on composition and digestibility of Coastal bermudagrass hay

Composition (averaged over harvest dates)[1]

Age at harvest (weeks)	CWC	ADF	Cellulose	AIL	Hemicellulose	CP
	----------	----------	----------	Percent	----------	----------
4	77.0^{a}	38.1^{a}	32.0^{a}	5.02^{a}	39.0^{a}	15.0^{a}
6	78.7^{b}	41.6^{b}	34.4^{b}	6.26^{b}	37.2^{b}	12.4^{b}
8	79.5^{b}	42.8^{b}	34.8^{b}	6.76^{b}	36.6^{b}	10.9^{c}

Digestibility (averaged over harvest dates)[2]

Age at harvest (weeks)	CWC	ADF	Cellulose	Hemicellulose	CP	DDM	IVDDM
	----------	----------	----------	Digestion coefficient, percent	----------	----------	----------
4	58.5^{a}	53.9^{a}	63.3^{a}	62.2^{a}	64.6^{a}	52.3^{a}	63.1^{a}
6	54.2^{b}	52.0^{b}	60.3^{b}	56.5^{b}	61.0^{b}	49.4^{b}	58.2^{b}
8	51.8^{c}	49.7^{c}	57.8^{c}	54.9^{c}	60.0^{b}	47.9^{c}	55.0^{c}

[1] [2] Means in the same column with different superscripts are significantly different ($P < .05$).

Table 5.—Intake values and average daily gains of beef steers fed Coastal bermudagrass hays harvested at three ages and five dates

Harvest date	Age of forage when cut			
	4 weeks	6 weeks	8 weeks	Means[1]
	Intake, percent of body weight			
June 14	2.39	2.41	2.39	2.40^a
July 12	2.22	2.54	2.03	2.26^a
Aug 9	2.30	2.07	1.79	2.05^a
Sept 6	2.39	2.27	2.16	2.27^a
Oct 4	2.32	2.36	1.66	2.11^a
Mean, age[2]	2.32^a	2.33^a	2.01^b	

Harvest date	Age of forage when cut			harvest date mean[1]
	4 weeks	6 weeks	8 weeks	
	Average daily gain, pounds			
June 14	.57	.34	.16	$.36^a$
July 12	.78	.48	.07	$.44^a$
Aug 9	.72	-.04	-.39	$.09^b$
Sept 6	.63	.42	.07	$.37^a$
Oct 4	.28	.22	-.39	$.04^b$
Mean, age[2]	$.59^a$	$.28^b$	$-.09^c$	

[1] Means in the same sub-column with different superscripts are significantly different ($P<.05$).

[2] Means in the same row with different superscripts are significantly different ($P<.05$).

analyses. All possible simple correlation coefficients (r values) among the variables evaluated are reported in Table 6.

Both intake and ADG means were negatively associated ($P<.01$) with all fibrous components of forage except hemicellulose. Highly significant ($P<.01$) positive relationships existed between ADG values and crude and digestible protein. Furthermore, there was a strong ($r=.72$) positive relationship between ADG and laboratory-estimated forage digestibility (IVDDM). Approximately 50 percent of the variation in ADG values was accounted for by differences in forage dry matter digestibility as determined by the in vitro procedure.

Laboratory values were not closely associated with voluntary intake, although several correlation coefficients were significant. Based on these data, intake of hays by the steers could not be estimated in the laboratory with any degree of accuracy.

Table 6.—Correlation coefficients among quality measurements of 15 Coastal bermudagrass hays

Variable	CWC	H. C.	ADF	Cell	AIL	CP	Dig.[1] prot.	IVDDM	DDM	ADG
Hemicellulose	.19									
ADF	.68**	-.58**								
Cellulose	.66**	-.50**	.93**							
AIL	.46**	-.64**	.87**	.71**						
C P	-.50**	.28	-.61**	-.62**	-.62**					
Dig. prot.	-.42**	.35*	-.62**	-.56**	-.60**	.70**				
IVDDM	-.61**	.50**	-.88**	-.73**	-.89**	.64**	.62**			
DDM	-.36*	.51**	-.72**	-.55**	-.72**	.32*	.62**	.79**		
ADG	-.56**	.34*	-.71**	-.61**	-.65**	.61**	.62**	.72**	.60**	
Intake	-.34*	.25	-.47**	-.42**	-.36	.25	.36*	.45**	.37*	.70**

[1] Digestible protein.
*Significant at ($P<.05$).
**Significant at ($P<.01$).

The apparent association between animal digestion values (DDM) and chemical analyses was highest for ADF and AIL (r= −.72). A limited relationship between CP and DDM (r=.32) was found, but a highly significant positive correlation (r=.62) was shown between DDM and digestible protein. The positive correlation of .79 ($P<.01$) between IVDDM and DDM values demonstrates that animal digestibility of the hays was predictable with considerable accuracy in the laboratory.

Summary

Coastal bermudagrass was harvested at five dates (June through October) and at three ages (4, 6, and 8 weeks) to determine the influence of harvest date and forage age on quality. Measurements used to evaluate quality were chemical analyses and digestibility of structural carbohydrates, protein, and dry matter. Animal performance data included voluntary intake and average daily gain.

Age of forage had a greater, more clearly defined effect on quality measurements than did date of harvest. Levels of all fibrous constituents except hemicellulose of the 4-week forage were lower ($P<.05$) than the respective values of the 6- and 8-week hays. There was a linear decrease ($P<.05$) in crude protein content as age of forage increased.

Furthermore, a linear decrease ($P<.05$) occurred in all fibrous constituent digestion values and in total dry matter content as forage age increased. Protein digestibility of the 4-week forage was higher ($P<.05$) than that of the 6- or 8-week hays, which were not significantly different.

Voluntary intake of the 8-week hay was less ($P<.05$) than that of the 4- and 6-week hays, which were not significantly different. The steer ADG decreased ($P<.05$) linearly with each increase in age of hay.

No trend was established regarding level of forage fibrous constituents with advancing season, although significant differences in this regard were found in the hays within each forage age. Small differences were found in CP content due to harvest date, but at all ages the June-harvested hays exhibited the lowest percentage of crude protein.

Small differences were noted in digestibility within the 4-week forage until the October harvest, but downward trends ($P<.05$) were noted within the 8-week hay after the July harvest. Smaller differences were found among digestion coefficients within the 6-week hays of different harvest dates than within either the 4- or 8-week hays.

No significant differences were found in voluntary intake of steers consuming hay from different harvest dates. The ADG values of steers consuming the August- and October-harvested hays were lower ($P<.05$) than gains by steers fed hay harvested at other dates.

All fibrous components, except hemicellulose, were negatively correlated with animal values. Crude and digestible protein and hemicellulose content were positively correlated with in vivo digestible dry matter, voluntary intake, and average daily gain. The laboratory measurement exhibiting the highest correlation with all animal values was in vitro digestible dry matter.

According to the data from this study, animals achieved maximum performance when consuming Coastal bermadagrass hay no more than 4 weeks of age harvested in June and July.

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Insects Infesting Alfalfa in Northwest Louisiana:

Their Effect on Production, Their Control with Insecticides

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LOUISIANA STATE UNIVERSITY
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Center for Agricultural Sciences
And Rural Development
ALVIN C. HARPER, CHANCELLOR
AGRICULTURAL EXPERIMENT STATION
DOYLE CHAMBERS, DIRECTOR

The Louisiana Agricultural Experiment Station follows a nondiscriminatory policy in programs and employment.

Abstract

Chapter I: Several potential insect pests, *Hypera postica* (Gyllenhal), *Lygus lineolaris* (Palisot de Beauvois), *Spissistilus festinus* (Say), *Acyrthosiphon pisum* (Harris), *Therioaphis maculata* (Buckton), 15 genera (14 species identified) of Cicadellidae, and some nonidentified Delphacidae, were collected from alfalfa fields during 1978. *H. postica* larvae were collected from March 17 to June 20, with peak populations occurring in mid-April. Adult *H. postica* were collected from mid-March through mid-June, and in December and February. *L. lineolaris* and *S. festinus* were collected throughout the year with population peaks observed in mid-June and mid-July respectively. *A. pisum* was collected in late March through mid-June and *T. maculata* from mid-August to late October and early November. Cicadellids were collected from early April through early November. *Graminella nigrifrons* (Forbes) was the predominant species.

Chapter II: Accumulated degree-days above base temperatures of 7°, 9°, and 10°C and from the starting dates of November 1, December 1, and January 1 were compared for use in predicting the appearance of alfalfa weevil larvae, *Hypera postica* (Gyllenhal), in Louisiana. The base temperatures tested were reliable for 2 years with only small differences occurring between years.

January 1 was the most reliable date for starting accumulation of degree-days above 7° and 9°C base temperatures. December 1 was the most accurate starting date for degree-days accumulation above the 10°C base.

Chapter III: Alfalfa stand loss was not affected by insect control with insecticides. All insecticide treatments exhibited visual phytotoxicity, and significant yield reductions occurred in methoxychlor+diazinon and carbaryl treatments (17.7 and 21.0 percent, respectively).

No significant differences existed in alfalfa weevil larvae control at 7 days posttreatment with several insecticides. At 14 days posttreatment, control with methidathion, carbofuran, carbaryl, methoxychlor+diazinon, and trichlorfon was significantly better than azinphosmethyl, chlorpyrifos, or check treatments. At 21 days posttreatment methidathion provided better control than azinphosmethyl, chlorpyrifos, or no treatments. Methyl parathion provided 91.2 and 89.9 percent weevil larvae control at 7 and 21 days posttreatment, respectively, in 1979. Only methidathion and methyl parathion provided acceptable control over the 21-day period. Low populations of the three-cornered alfalfa hopper, *Spissistilus festinus* (Say), and the tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois), were not reduced with any of the insecticides tested.

Preface

During the last two decades, alfalfa acreage and production has dwindled in northwest Louisiana due to difficulty in maintaining sufficient stands and yields. However, the building of a horse race track in Bossier Parish has increased local demand for quality hay and has renewed interest in alfalfa production. The study reported herein was conducted to gain more knowledge concerning the insect fauna present in alfalfa fields and to evaluate their effect on crop production of alfalfa in northwest Louisiana.

The research reported is presented in three independent chapters. Chapter I pertains to the identification and seasonal occurrence of insects recognized as pests or potential pests. Chapter II presents the results of a study designed to determine if the appearance of alfalfa weevil larvae in northwest Louisiana could be accurately predicted using accumulated degree-days. Chapter III deals with the effect of insects on alfalfa yield and stand loss. Insecticidal control, primarily with compounds presently labeled for use in Louisiana, was also evaluated.

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Insects Infesting Alfalfa in Northwest Louisiana: Their Effect on Production, Their Control with Insecticides

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and K. L. Koonce[3]

Chapter I: Identification and Seasonal Occurrence of Alfalfa Insect Pests in Northwest Louisiana

Introduction

Various aspects of the biology of several insects that feed on and damage alfalfa have been studied. Manglitz and App (1957), Campbell, et al. (1961), Pitre (1969), and Blickenstaff, et al. (1972) are among the workers who have studied the biology of the alfalfa weevil, *Hypera postica* (Gyllenhal). Wheeler (1974) reported on the biology and seasonal abundance of the tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois). The occurrence and abundance of the potato leafhopper, *Empoasca fabae* (Harris), as affected by alfalfa cutting schedules has been examined by Searls (1934) and Pienkowski and Medler (1962).

An extensive survey of pest insects infesting alfalfa and their pest potential has not been published in Louisiana. These data are intended to meet this need by identifying species that feed on alfalfa and determining their seasonal occurrence.

Methods and Materials

The study was conducted at the Red River Valley Agricultural Experiment Station near Bossier City from March 1978 to March 1979 on a third-year stand of "Buffalo" alfalfa, *Medicago sativa* L. The crop was managed according to normally accepted agronomic practices, with the exception that no insecticides were applied. Test plots were harvested April 24, May 30, June 26, July 27, and August 24, 1978. Two series of plots (untreated checks in other tests), each replicated four times, were sampled during the study period. Plot size ranged from 9.29 m^2 (100 ft^2) to 116.17 m^2 (1,250 ft^2).

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Insect populations were sampled at 1- or 2-week intervals during active alfalfa growth and monthly during the winter. Sweep samples were taken with a standard 38.1 cm (15.0 in) diameter sweep net. Five or 10 horizontal 180° sweeps were taken along a transect near the center of each 9.29 m^2 (100 ft^2) and 116.17 m^2 (1,250 ft^2) test plot, respectively. Samples were placed in plastic bags, chilled in an ice chest, and transported to the laboratory for processing and identification of insects. Seasonal occurrence of each species was determined and expressed as insects per sweep.

Results and Discussion

The most numerous insects known to be pests of alfalfa in northwest Louisiana that were collected in this study are listed in Table 1. Alfalfa weevil, *Hypera postica* (Gyllenhal), larvae were taken from March 17 until June 20, 1978 (Figure 1). The larval population peaked April 11 at 15.67 larvae per sweep and was comparable to the late March to mid-April peak found by Pitre (1969) in Mississippi. Few adult weevils were collected from mid-March until mid-June and in December and February. The tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois), was collected from mid-March until mid-December with the greatest population observed in mid-June at 1.85 bugs per sweep. The three-cornered alfalfa hopper, *Spissistilus festinus* (Say), was collected from mid-March until mid-December with peak populations occurring in mid-July and in mid-October. The October rise apparently was an influx from adjacent fields of maturing soybeans.

Leafhoppers, Cicadellidae, and planthoppers, Delphacidae, were collected from early April until early November (Figure 1). Populations peaked in mid-June at 2.66 per sweep. The leafhopper-planthopper complex consisted of 15 genera. Fourteen members of the complex were identified to species (Table 1) with seasonal occurrence varying with species (Figure 2). *Graminella nigrifrons* (Forbes) was the predominant leafhopper species collected throughout the year (Table 2).

Graminella nigrifrons, Exitianus exitiosus (Uhler), *Nesosteles neglecta* (Delong and Davidson), and *N. guajanae* (Delong) are grass feeders (Delong 1948, Osborn 1912, Delong and Davidson 1935, Caldwell and Martorell 1952). These species were feeding on grassy weeds, primarily *Brachiaria platphylla* (Griseb.), in the alfalfa. When grass-feeding species (67.7 percent of the total leafhopper-planthopper population) were

Table 1.—Major recognized alfalfa insect pests collected in alfalfa fields by sweep net, Red River Valley Agricultural Experiment Station, 1978-79

Order	Family	Genus	Species
Hemiptera			
	Miridae		
		Lygus	*lineolaris* (Palisot de Beauvois)
Homoptera			
	Aphididae		
		Acyrthosiphon	*pisum* (Harris)
		Therioaphis	*maculata* (Buckton)
	Cicadellidae		
		Aceratagallia	*sanguinolenta* (Provancher)
		Agallia	*constricta* (Van Duzee)
		Carneocephala	*flaviceps* (Riley)
		Cuerna	*costalis* (Fabricius)
		Draeculacephala	spp.
		Empoasca	spp.
		Exitianus	*exitiosus* (Uhler)
		Graminella	*nigrifrons* (Forbes)
		Nesosteles	*guajanae* (Delong)
		Nesosteles	*neglecta* (Delong & Davidson)
		Norvelina	*seminuda* (Say)
		Planicephalus	*flavicosta* (Stal)
		Scaphytopius	*acutus* (Say)
		Scaphytopius	*frontalis* (Van Duzee)
		Stirellus	*bicolor* (Van Duzee)
		Texananus	*excultus* (Uhler)
		Typhlocyba	spp.
	Delphacidae		
	Membracidae		
		Spissistilus	*festinus* (Say)
Coleoptera			
	Curculionidae		
		Hypera	*postica* (Gyllenhal)

excluded, the number feeding on alfalfa was relatively small. This may be a result of harvest frequency as noted previously by Searls (1934) and Pienkowski and Medler (1962).

Two aphid species were collected from alfalfa during 1978. The pea aphid, *Acyrthosiphon pisum* (Harris), was collected from late March until mid-June (Figure 1) with a peak population observed in mid-May at 19.85 aphids/sweep. The spotted alfalfa aphid, *Therioaphis maculata* (Buckton), was collected in mid-August, in October and early November, with the largest population (4.48/sweep) present in mid-August.

Several pestiferous *Lepidoptera*, (the alfalfa caterpillar, *Colias eurytheme* (Boisduval); the beet armyworm, *Spodoptera exigua* (Hubner);

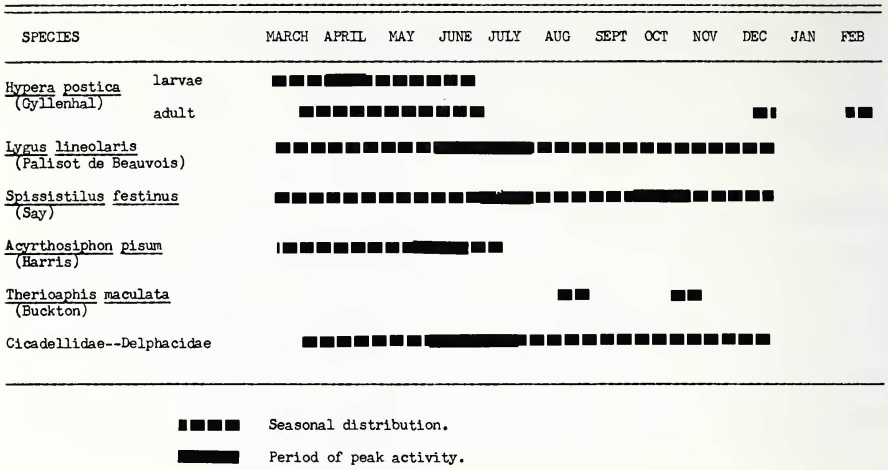

Figure 1.—Species and seasonal occurrence of major recognized pest insects of alfalfa in northwest Louisiana, 1978.

the green cloverworm, *Platypena scabra* (Fabricius); the velvetbean caterpillar, *Anticarsia gemmatalis* (Hubner); and *Heliothis* spp.) were collected but not studied extensively because of low numbers and sporadic collections.

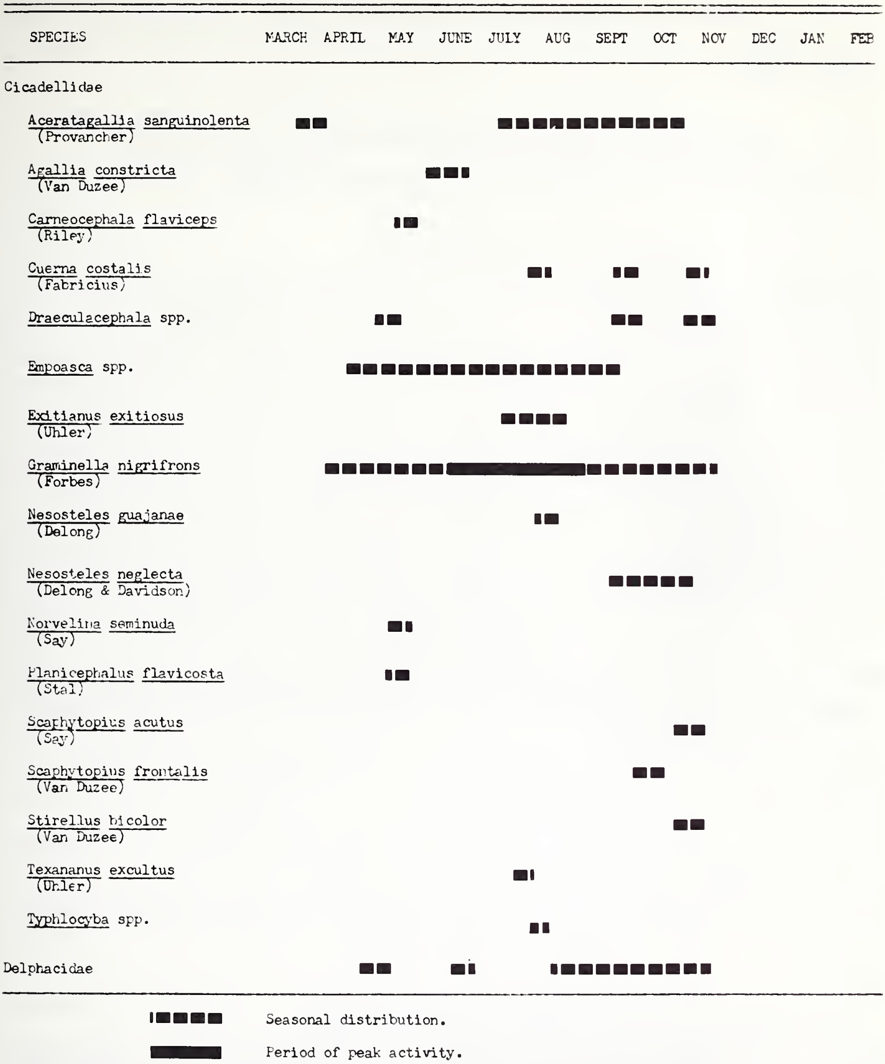

Figure 2.—Species and seasonal occurrence of Cicadellidae and Delphacidae in alfalfa fields in northwest Louisiana, 1978.

Table 2.—Leafhoppers and planthoppers collected in alfalfa fields and percent of the total comprised by each species at the Red River Valley Agricultural Experiment Station, 1978

Species	Composition %
Graminella nigrifrons (Forbes)	63.1
Aceratagallia sanguinolenta (Provancher)	7.6
Empoasca spp.	7.1
Delphacidae	5.7
Agallia constricta (Van Duzee)	3.1
Nesosteles neglecta (Delong & Davidson)	2.8
Planicephalus flavicosta (Stal)	2.1
Exitianus exitiosus (Uhler)	1.6
Typhlocyba spp.	1.6
Draeculacephala spp.	1.4
Cuerna costalis (Fabricius)	0.9
Scaphytopius frontalis (Van Duzee)	0.9
S. acutus (Say)	0.7
Carneocephala flaviceps (Riley)	0.2
Nesosteles guajanae (Delong)	0.2
Norvelina seminuda (Say)	0.2
Stirellus bicolor (Van Duzee)	0.2
Texananus excultus (Uhler)	0.2

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Chapter II: Predicting Spring Appearance of Alfalfa Weevil Larvae in Northwest Louisiana

Introduction

Prediction of spring appearance of *Hypera postica* (Gyllenhal), using accumulated degree-days (Roberts, et al., 1970), is highly useful to farmers and pest management consultants. However, the most reliable temperature base and starting date for such predictions under Louisiana conditions were unknown. Reported here are results of a study conducted to determine the proper temperature base to initiate degree-day accumulations to predict alfalfa weevil appearance in northwest Louisiana.

Several reports exist relative to theoretical base temperatures for embryonic development of the alfalfa weevil. Roberts, et al. (1970) calculated a starting base temperature of 7°C, and using accumulated degree-days above 7°C, found an average 313 degree-days required for 50 percent hatch indoors and 229 degree-days outdoors. Litsinger and Apple (1973) concluded that 10°C was a more reliable base temperature and found that 176 and 205 degree-days were required for first and 50 percent hatch, respectively, in the laboratory. Outdoors, they found that 168 and 189 degree-days were required for first and 50 percent hatch respectively. Sweetman and Wedemeyer (1933) and Koehler and Gyrisco (1961) found a base temperature of 10°C yielded the most accurate degree-day prediction. Wedberg, et al. (1977) using a 9°C base temperature suggested field sampling begin when 200 degree-days have accumulated beginning with January 1, where fall and winter egg-laying occurs.

Methods and Materials

A study was conducted near Bossier City at the Red River Valley Agricultural Experiment Station in "Buffalo" alfalfa during 1978 and 1979 and in "Oklahoma" alfalfa at the nearby White Farm in 1979. Fields were sampled weekly by examining 30 stems and by making 40 sweeps from each field for appearance of the first larvae.

The number of accumulated degree-days from the previous November 1, December 1, and January 1 to the appearance of larvae were calculated for the base temperatures 7°, 9°, and 10°C. The degree-day values above the appropriate base temperature for each day were summed from each starting date to the date of first larval appearance. Accumulated degree-day values for the base temperature equivalents in degrees Fahrenheit were calculated according to Roberts, et al. (1970) and are included for comparison of accumulated degree-days values with those reported previously.

Temperature records for both test sites were obtained from the official National Weather Service station located at the Red River Valley Agricultural Experiment Station.

Results and Discussion

The first larvae in the spring were collected on March 17 and March 1 in 1978 and 1979, respectively. Differences among the three test dates in degree-days above the 7° and 9°C base temperatures for the 2 years were smallest for January 1 (6.5 and 1.3 degree-days respectively), Table 1. However, in 1979, accumulated degree-days (333) for December 1 at the 7°C base were within the range required for 50 percent hatch found by Roberts, et al. (1970). Degree-day values summed for December 1 (225.5 and 214) above the 9°C base also were comparable to the 200 degree-days required for hatch noted by Wedberg, et al. (1977). Accumulated degree-day differences for the 2 years above the 10°C base were smallest for December (2.5). The 168 degree-days observed for December 1, 1978 was identical to that reported for first hatch by Litsinger and Apple (1973).

Although degree-day values for December 1 above the 7°, 9°, and 10°C bases were comparable to earlier reported values required for 1st hatch, the least variation between years for the degree-day values in the study for the 7° and 9°C temperature bases occurred when degree-day accumulation was begun January 1 with only a slight increase in variation between years for January 1 (2.5 to 7.0)

Table 1.—Degree-day accumulation to first larval appearance of the alfalfa weevil for three base temperatures and three starting dates in Northwest Louisiana, 1978-79

		Accumulated degree-days[1]		
Base temperature		November 1	December 1	January
7°C (44.5°F)	1978	395.5 (736.0)	188.3 (342.0)	101.9 (185.0)
	1979	418.8 (767.5)	172.1 (333.0)	95.4 (182.5)
	Difference	23.3 (31.5)	16.2 (9.0)	6.5 (2.5)
9°C (48°F)	1978	292.5 (507.5)	139.0 (225.5)	67.3 (124.0)
	1979	308.5 (548.5)	117.5 (214.0)	68.6 (125.5)
	Difference	16.0 (41.0)	21.5 (11.5)	1.3 (1.5)
10°C (50°F)	1978	222.8 (400.0)	93.6 (168.0)	51.6 (93.0)
	1979	262.3 (458.0)	96.1 (173.0)	58.6 (105.5)
	Difference	39.5 (58.0)	2.5 (5.0)	7.0 (12.5)

[1] Values in parentheses are based on °F; values not in parentheses are based on °C.

Conclusions

Predicting spring hatch of the alfalfa weevil with degree-day accumulation can be used effectively in Louisiana. Base temperatures of 7°, 9°, and 10°C can be used reliably. The most accurate starting date for degree-day accumulations in Louisiana was January 1 for either a 7° or a 9°C base and December 1 for a 10°C base. Field sampling should begin when approximately 85, 65, and 90 degree-days have accumulated above the 7°, 9°, and 10°C bases, respectively.

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Chapter III: Effect on Production and Control with Insecticides of Alfalfa Insects in Northwest Louisiana

Introduction

Alfalfa yield reduction by insects has been well documented. Losses attributable to *Lygus* spp.; the pea aphid, *Acyrthosiphon pisum* (Harris); the alfalfa weevil, *Hypera postica* (Gyllenhal); and the potato leafhopper, *Empoasca fabae* (Harris), have been reported by Stitt (1948), Harper and Lilly (1966), Armbrust, et al. (1968), and Kouskolekas and Decker (1968). During the last two decades, the maintenance of sufficient alfalfa stands for profitable yields has become difficult for northwestern Louisiana farmers. Alfalfa production, which once flourished in this region, has dwindled to a relatively low acreage in spite of increased demand for alfalfa hay. The economic advantage for alfalfa produced in northwest Louisiana dictated a need (1) to determine the effect of insect pests on alfalfa yield and stand loss, (2) to evaluate available insecticide control measures for these pests, and (3) to determine the best-suited insecticides for Louisiana conditions.

Methods and Materials

Research was conducted at the Red River Valley Agricultural Experiment Station near Bossier City in a third-year stand of ''Buffalo'' alfalfa from March 1978 to March 1979. Several insecticides were field tested for efficacy as foliar sprays under northwest Louisiana conditions. A randomized block design with each treatment replicated four times was employed in this experiment. In addition to monitoring insect populations, yield and stand counts were determined. Individual test plots were 116.7 m^2 (1,248 ft^2) in size and managed according to normally accepted agronomic practices. They were harvested April 24, May 30, June 26, July 27, and August 24, 1978.

Insecticides were applied with a Hahn ''Hy-boy'' in 56.9 liters of water per hectare (15 gal/ac) at the recommended label rates. Treatments, with label restrictions included:

Insecticide	Rate, active ingredients, per hectare
azinphosmethyl	0.28 kg (.127 lb) once to stubble and 10 to 14 days later
carbaryl	1.12 kg (2.5 lbs) weekly
carbofuran +	1.12 kg (2.5 lbs) alfalfa weevil only, one application per season
methyl parathion	0.56 kg (1.25 lbs) up to 15 days before harvest
chlorpyrifos	1.12 kg (2.5 lbs) (not labeled by EPA for application to alfalfa)
methidathion	1.12 kg (2.5 lbs) once to stubble and 10 to 14 days later
methoxychlor+diazinon*	1.34 kg (3.0 lbs) + 0.67 kg (1.5 lbs) weekly up to 7 days before harvest
trichlorfon	1.12 kg (2.5 lbs) three applications per harvest
check — untreated	—

Carbaryl, methoxychlor+diazinon,* and trichlorfon were applied March 29, April 7, May 9, June 14, and July 13. Azinphosmethyl and methidathion were applied March 29, May 9, June 14, and July 13. Insecticides were applied when insect populations reached levels deemed sufficient for efficacy testing and/or causing visual damage to the crop.

In another experiment, the field efficacy of methyl parathion for alfalfa weevil larvae control was tested March 6, 1979, in the same alfalfa field described previously. Methyl parathion was applied as a foliar spray at 0.56 kg ai/hectare (1.25 lbs/ac) in 56.9 liters (15 gal) water replicated three times and compared with a non-treated control.

Plots in all tests were harvested with a flail chopper. Yield samples were taken by removing the alfalfa within a 9.29 m^2 (100 ft^2) area from the center of each plot at each harvest. The alfalfa from the sample area was weighed for green weight yield. To obtain dry weight yields, a 2.27 kg (5.0 lbs) sample was taken from each green yield sample and oven dried at 40°C until consecutive weights were consistent.

Insect populations were sampled either weekly or biweekly, as populations dictated, throughout the growing season by making 10 horizontal 180° sweeps along a central transect in each plot with a standard 38.1 cm (15 in) diameter sweep net. Samples were stored in plastic bags until they could be sorted, counted, and identified. Treatment means were separated by Duncan's New Multiple Range Test. Percent control was calculated by Abbott's Formula (Abbott, 1925).

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*Alfa-Tox, product of Ciba-Geigy Corporation, a mixture containing 20 percent methoxychlor and 10 percent diazinon.

Stand loss in each test plot was measured by making stand counts in March and November, 1978 and March 1979. Counts were made by dropping a wood frame (inside area 929 cm^2) (1.0 ft^2) at three random locations in each plot. The number of clones enclosed by the frame was counted and used to calculate the mean number of clones/929 cm^2 (1.0 ft^2).

Similar stand counts were taken November 1976, October 1977, and November 1978 in an adjacent test in the same field. In this test, plots (9.29 m^2) (100 ft^2) were replicated four times. The following insecticide treatments were applied at 2.24 kg ai/ha (5.0 lbs/ac): carbaryl spray, carbaryl 10 percent granules, carbofuran spray, carbofuran 10 percent granules, heptachlor 10 percent granules, and chlordane 10 percent granules. An untreated check was included. Granular formulations were applied broadcast October 14, 1976 and March 29, 1977. Liquid formulations were applied biweekly as foliar sprays October 1976 to October 1977. All treatments received as foliar sprays carbofuran (1.12 kg ai/ha) (2.5 lbs/ac) on March 29 and methyl parathion (0.56 kg ai/ha) (1.25 lbs/ac) on May 9, June 14, and July 13, 1978.

Results and Discussion

Pest insects found in the test fields included the alfalfa weevil, *Hypera postica* (Gyllenhal); the three-cornered alfalfa hopper, *Spissistilus festinus* (Say); the tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois); the pea aphid, *Acyrthosiphon pisum* (Harris); and a leafhopper-planthopper complex consisting of 12 genera. Ten members of the complex were identified to species. Alfalfa weevil larvae, the three-cornered alfalfa hopper, and the tarnished plant bug reached population peaks of 18.1, 2.18, and 1.45/sweep, respectively, in untreated plots. The leafhopper-planthopper complex occurred in low numbers (less than 0.5/sweep), while the maximum pea aphid population observed was 16.88/sweep.

No significant difference existed among the test insecticides for alfalfa weevil larvae control at 7 days posttreatment (Table 1). At 14 days posttreatment, control with methidathion, carbofuran, carbaryl, methoxychlor+diazinon, and trichlorfon was significantly better than with azinphosmethyl, chlorpyrifos, or the check. At 21 days posttreatment, methidathion provided better control than azinphosmethyl, chlorpyrifos, trichlorfon, and the check; carbofuran, carbaryl, methoxychlor+diazinon, and trichlorfon provided better control than azinphosmethyl, chlorpyrifos, and the check.

Methyl parathion provided 91.2 and 89.9 percent control of weevil larvae at 7 and 21 days posttreatment, respectively, in 1979 (Table 2). Only methidathion and methyl parathion provided an acceptable level of control

Table 1.—Field efficacy of selected insecticides for control of alfalfa weevil larvae, *Hypera postica* (Gyllenhal), infesting alfalfa, Red River Valley Agricultural Experiment Station, 1978

Treatment[1], kg ai/ha (lbs ai/ac)		Mean no. larvae/sweep[2] and % control[3]					
		7 days post-treatment	% control	14 days post-treatment	% control	21 days post-treatment	% control
Methidathion	1.12 (2.5)	0.93 a	94.0	0.05 a	99.7	0.88 ab	95.4
Carbofuran	1.12 (2.5)	0.88 a	94.4	1.35 a	92.5	3.98 bc	78.0
Carbaryl	1.12 (2.5)	1.90 a	90.5	3.45 a	84.9	7.03 bc	71.4
Methoxychlor+–diazinon	1.34 + 0.67 (3.0 + 1.5)	1.93 a	86.0	1.18 a	92.5	4.0 bc	76.4
Azinphosmethyl	0.28 (0.6)	2.68 a	85.8	10.75 b	50.3	23.7 d	0.0
Chlorpyrifos	1.12 (2.5)	2.50 a	83.3	14.73 b	14.4	17.5 d	4.3
Trichlorfon	1.12 (2.5)	3.45 a	71.3	2.13 a	84.5	9.73 c	33.9
Check — untreated		14.83 b	—	16.98 b	—	18.10 d	—

[1] Treatments applied March 29, 1978. A second application of carbaryl, methoxychlor+diazinon and trichlorfon applied 9 days later.

[2] Means within columns assigned the same letter are not significantly different at the 5 percent level by Duncan's New Multiple Range Test.

[3] Calculated by Abbott's formula.

Table 2.—Field efficacy of methyl parathion for control of alfalfa weevil larvae, *Hypera postica* (Gyllenhal), Red River Valley Agricultural Experiment Station, 1979

Treatment[1], kg ai/ha (lbs ai/ac)	Mean no. larvae/sweep[2] and % control[3]			
	7 days posttreatment	% control	21 days posttreatment	% control
Methyl parathion 0.56 (1.25)	0.66 a	91.2	3.46 a	89.9
Check — untreated	5.96 b	—	26.96 b	—

[1] Treatment applied March 6, 1979.

[2] Means within columns assigned the same letter are not significantly different at the 5 percent level by Duncan's New Multiple Range Test.

[3] Calculated by Abbott's formula.

over the 21-day period. The three-cornered alfalfa hopper and tarnished plant bug were not controlled effectively with any of the test materials. (Tables 3 and 4, respectively).

No significant increase in yields occurred in response to insecticide treatment (Table 5). The methoxychlor+diazinon-treated plots yielded significantly less than the check and methidathion-treated plots. Carbaryl-treated plots yielded significantly less than the check, methidathion- and trichlorfon-treated plots. Phytotoxicity was evident in all insecticide treatments applied prior to first harvest. By visual evaluation, phytotoxicity was most severe in carbofuran, azinphosmethyl, methoxychlor+diazinon, and carbaryl treatments, and subsequent total yields reflected these adverse phytotoxic effects.

Moreover, a nonvisual phytotoxic effect may have existed in some plots during the later harvest periods that resulted in lower yields than the check on specific harvest dates and for total annual yield. Phytotoxicity by azinphosmethyl, diazinon, methyl parathion, and methoxychlor has been noted by Forsythe, et al. (1962), Depew (1969), and Armbrust, et al. (1968). Methoxychlor+diazinon and carbaryl also exhibited phytotoxic effects in Mississippi, Anon. (1967).

Table 3.—Field efficacy of selected insecticides for control of the three-cornered alfalfa hopper, *Spissistilus festinus* (Say), Red River Valley Agricultural Experiment Station, 1978

Treatment[1], kg ai/ha (lbs ai/ac)		Mean no. alfalfa hoppers/sweep[2] and % control[3]	
		5 days posttreatment	% control
Methoxychlor+diazinon	1.34+0.67 (3.0+1.25)	0.68 a	70.3 a
Azinphosmethyl	0.28 (0.6)	0.80 a	46.4 a
Chlorpyrifos	1.12 (2.5)	0.90 a	46.3 a
Trichlorfon	1.12 (2.5)	0.73 a	44.2 a
Carbaryl	1.12 (2.5)	0.68 a	41.7 a
Methidathion	1.12 (2.5)	0.95 a	34.3 a
Methyl parathion	0.56 (1.25)	1.28 a	22.4 a
Check — untreated		1.33 a	—

[1] Treatments applied July 13, 1978.

[2] Mean of four replications. Means within columns assigned the same letter are not significantly different at the 5 percent level by Duncan's New Multiple Range Test.

[3] Calculated by Abbott's formula.

Although significant yield increases were not realized when insects were controlled, yields in the methidathion-treated plots for the first two harvest dates were higher where phytotoxicity was less severe and control of alfalfa weevil larvae was satisfactory.

Alfalfa stand loss was not significantly retarded by controlling insects. However, progressive, highly significant stand decreases occurred over all treatments between November 1976 and November 1978 in the 9.29 m^2 (100 ft^2) plots (Table 6), and between March and November 1978 in the insecticide evaluation plots (Table 7). No significant decreases in stand occurred from November 1978 to March 1979.

Table 4.—Field efficacy of selected insecticides for control of the tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois) infesting alfalfa, Red River Valley Agricultural Experiment Station, 1978

Treatment[1], kg ai/ha (lbs ai/ac)		Mean no. plant bugs/sweep[2] 7 days posttreatment	% control[3]
Methoxychlor+diazinon	1.34+0.67 (3.0+1.25)	0.70 a	28.0 a
Methidathion	1.12 (2.5)	0.85 a	22.6 a
Chlorpyrifos	1.12 (2.5)	0.85 a	15.0 a
Azinphosmethyl	0.28 (0.6)	0.83 a	9.0 a
Carbaryl	1.12 (2.5)	0.60 a	0.0 a
Methyl parathion	0.56 (1.25)	0.90 a	0.0 a
Trichlorfon	1.12 (2.5)	0.90 a	0.0 a
Check — untreated		0.75 a	—

[1] Treatments applied June 14, 1978.

[2] Mean of four replications. Means within columns assigned the same letter are not significantly different at the 5 percent level by Duncan's New Multiple Range Test.

[3] Calculated by Abbott's formula.

Table 5.—Yield of Buffalo alfalfa in response to insect control with selected insecticides, Red River Valley Agricultural Experiment Station, 1978

Treatment[1]	Harvest date					
	4/24	5/30	6/26	7/24	8/24	Total
	Yield[3]					
Check — untreated	2,711.30 a[2]	3,988.52 a	2,711.30 a	1,635.71 a	1,971.87 a	13,018.71 a
	(5,964.80)	(8,793.1)	(5,977.3)	(3,606.1)	(4,347.2)	(28,701.0)
Methidathion	3,204.25 a	4,212.61 a	2,711.30 a	1,389.24 a	1,411.69 a	12,929.09 a
	(7,049.24)	(9,287.1)	(5,977.3)	(3,062.7)	(3,112.2)	(28,503.5)
Trichlorfon	2,576.84 a	3,585.19 a	2,957.77 a	1,658.16 a	1,680.55 a	12,458.52 ab
	(5,668.96)	(7,903.9)	(6,520.7)	(3,655.6)	(3,705.0)	(27,466.0)
Chlorpyrifos	2,733.69 a	3,450.73 a	2,778.53 a	1,322.07 a	1,613.32 a	11,898.34 abc
	(6,013.92)	(7,607.5)	(6,125.5)	(2,914.6)	(3,556.7)	(26,231.1)
Carbofuran + methyl parathion	2,733.69 a	3,943.74 a	2,375.20 a	1,232.38 a	1,344.46 a	11,629.47 abc
	(6,013.92)	(8,694.4)	(5,236.4)	(2,716.9)	(2,964.0)	(25,638.3)
Azinphosmethyl	2,509.67 a	3,473.18 a	2,419.98 a	1,411.69 a	1,366.85 a	11,181.36 abc
	(5,521.27)	(7,657.0)	(5,335.1)	(3,112.2)	(3,013.3)	(24,650.4)
Methoxyclor + diazinon	2,375.20 a	3,204.25 a	2,397.59 a	1,366.85 a	1,501.31 a	10,845.50 bc
	(5,225.44)	(7,064.1)	(5,285.7)	(3,013.3)	(3,309.8)	(23,910.0)
Carbaryl	1,927.03 a	3,383.50 a	2,173.51 a	1,254.83 a	1,568.54 a	10,307.04 c
	(4,239.46)	(7,459.3)	(4,791.7)	(2,766.4)	(3,458.0)	(22,722.9)

[1] Carbaryl, methoxychlor+diazinon, and trichlorfon applied March 29, April 7, May 9, June 14, and July 13; azinphosmethyl and methidathion applied March 29, May 9, June 14, and July 13; chlorpyrifos applied March 29, June 14, and July 13; carbofuran applied March 29; methyl parathion applied May 9, June 14, and July 13.

[2] Means within columns assigned the same letter are not significantly different at the 5 percent level by Duncan's New Multiple Range Test.

[3] Numbers in parentheses = lbs/ac; numbers not in parentheses = kg/ha.

Table 6.—Alfalfa stand counts as affected by applications of selected insecticides, Red River Valley Agricultural Experiment Station, 1976-78

Treatment[1]	Mean[2] no. clones/929 cm^2 (clones/ft^2)		
	11-18-76 a	10-27-77 b	11-1-78 c
Carbaryl spray	9.00 a	4.75 a	3.63 a
10% granules	8.00 a	5.13 a	3.50 a
Carbofuran spray	7.50 a	5.00 a	3.25 a
10% granules	8.00 a	4.88 a	3.63 a
Heptachlor 10% granules	9.13 a	3.88 a	2.75 a
Chlordane 10% granules	6.75 a	3.88 a	3.38 a
Check — untreated	8.38 a	5.13 a	2.88 a

[1] Treatments listed were applied November 1976-October 1977. All test plots were treated in 1978 with carbofuran (1.12 kg ai/ha) (2.5 lbs/ac) March 29 and methyl parathion (0.56 kg ai/ha) (1.25 lbs/ac) May 9, June 14, and July 13, 1978.

[2] Means within columns and among dates with the same letter assigned are not significantly different at the 1 percent or 5 percent level by Duncan's New Multiple Range Test.

Table 7.—Alfalfa stand counts as affected by application of selected insecticides, Red River Valley Agricultural Experiment Station, 1978-79

Treatment	Mean[1] no. clones/929 cm^2 (clones/ft^2) 3-29-78 a	11-1-78 b	3-12-79 b
Azinphosmethyl	4.08 a	2.75 a	2.75 a
Carbaryl	3.50 a	2.58 a	2.83 a
Carbofuran + methyl parathion	4.00 a	3.00 a	2.83 a
Chlorpyrifos	4.25 a	3.42 a	2.75 a
Methidathion	4.25 a	3.08 a	2.67 a
Methoxychlor+diazinon	3.91 a	3.00 a	2.50 a
Trichlorfon	4.00 a	2.67 a	2.83 a
Check — untreated	4.25 a	2.75 a	2.91 a

[1] Means within columns and among dates with the same assigned letter are not significantly different at the 1 percent or 5 percent level by Duncan's New Multiple Range Test.

Conclusions

All labeled insecticides tested produced phytotoxic effects when applied to alfalfa under Louisiana conditions. With the possible exception of the alfalfa weevil, economic injury thresholds of alfalfa insect pests as established elsewhere would require adjustment for Louisiana conditions to consider yield reduction caused by the phytotoxic effects of the insecticides. Weevil larvae have been observed in other years at much higher population levels than occurred during this study, and control would be necessary to prevent almost complete loss of the alfalfa crop at high population levels.

Of the insecticides tested, only methidathion and methyl parathion provided satisfactory control of alfalfa weevil larvae with an acceptable amount of phytotoxicity.

Insects do not appear to be the cause of alfalfa stand loss in northwest Louisiana. The fact that stand loss did not differ significantly between treatments where insects were controlled and treatments in which they were not controlled during a 2½ year test period but differed significantly over time in all treatments indicates that further research is needed to solve the stand loss problem.

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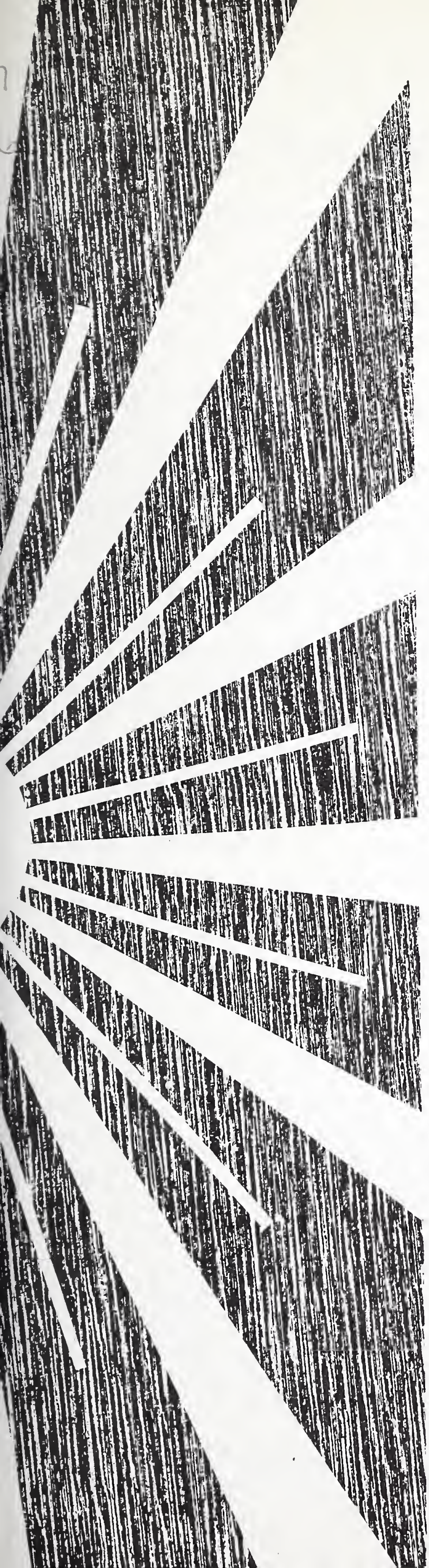

SOLAR DRYING OF WOOD IN LOUISIANA

by Timothy G. Lumley
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Solar Drying of Wood in Louisiana

TIMOTHY G. LUMLEY AND ELVIN T. CHOONG[1]

Introduction

The energy crisis of the 1970's has stimulated research and development of several energy forms. One possible source of clean, inexhaustible energy is the sun.

There are two serious limitations to the effective use of solar energy. Most apparent is the intermittent availability of the energy. A process that requires a constant heat source would necessitate development of some form of energy storage for use at night and on cloudy days. The second major limitation is that solar energy is in a nonconcentrated form. To obtain large quantities of energy, the radiant energy from the sun, called the insolation, over a large surface area must be captured.

When these two limitations are overcome, our most abundant energy source can be harnessed. The sun's unlimited energy supply need not be conserved. Each day's solar energy is free and any not used will be re-radiated back into space. Solar energy produces no toxic waste or pollutants. Because the energy can be captured near its point of use, transportation and distribution costs could be low or nonexistant. Solar energy is a safe energy source, and reliance on it would provide an equitable means to allocate energy resources among generations.

If solar energy could be effectively used to dry lumber, a clean, inexpensive energy source would be available to lumbermen, and part of the nation's energy resources could be conserved. Although most hardwoods are dried at temperatures easily obtained by flat-plate collectors, a large lumber kiln requires much energy to dry green lumber. A large solar collector, with a consequently large capital investment, is therefore necessary to fully utilize solar heat for lumber drying.

Analysis by Lumley and Choong (1979) showed that use of commercial solar collectors at installed prices of $20 per square foot or more was not economically justified in Louisiana at that time. Areas with more usable solar radiation or higher fuel prices might be able to justify somewhat higher collector prices, but even with recent fuel price increases it is doubtful that expensive commercial solar collectors are economically competitive for lumber seasoning as yet.

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For a solar kiln to be commercially feasible, the collector's cost must be reduced. Integrating the collectors into a kiln structure may help by reducing total construction cost. However, a computerized modification of a heat consumption model (Shottafer and Shuler, 1974) that considered diurnal temperature fluctuations of a solar kiln showed that sufficient solar collector area cannot be incorporated into a kiln's structure without some modifications in drying methodology or traditional kiln design. Furthermore, conventional kiln structures are not geometrically optimal for solar collector orientation. If solar collectors could be used to form the exterior surface of the kiln structure, provisions should be made to thermally isolate them from the kiln's interior to prevent nightly heat losses.

Compounding the problem of sufficient heat collection is moisture removal. Wood with a specific gravity of .56 will lose 39.2 pounds of water per cubic foot when dried from a moisture content 120 percent to 8 percent. A 50,000 bd-ft kiln would therefore have to remove 163,333 pounds (19,560 gal) of water. Traditionallty, moisture is removed by venting the moisture-laden air to the outside of the kiln, replacing it with freshly heated air. A venting function in a solar kiln would seem to necessitate some form of heat storage to heat replacement air at night or on cloudy days.

The main purposes of this study were (1) to design, construct, and evaluate a small forced air solar lumber kiln, and (2) to establish the relationship of Louisiana climatic and solar insolation data to solar drying of different wood species. The results of this study provide basic information about the state-of-the-art of solar energy for application in wood processing.

Literature Review

Research during the past 20 years has led to the development of two major solar kiln types, the most common being the so-called "greenhouse" type. These kilns were typically wood frame structures covered on the roof and three walls by translucent glazing materials. Blackened aluminum plates on the interior serve as heat collecting (blackbody) surfaces. Such kilns are inexpensive, easy to design and build, and simple to operate, but tend to have radical diurnal temperature fluctuations due to substantial nightly heat losses. These kilns have been successfully demonstrated on a small scale in the United States (Peck, 1962; Maldonado and Peck, 1962; Chudnoff et al. 1966; Troxell and Mueller, 1968) and in several developing countries (Plumptre, 1967; 1973; Casin et al. 1969) but seem to have practical size limitations because the volume (capacity) of such structures increases faster than the surface area needed to collect solar energy.

A second type of solar kiln consists of an enclosed drying chamber and some form of external (to the chamber) collector. The drying chamber can be insulated to reduce diurnal temperature fluctuations and thus give more control over drying conditions, but these kilns are more complicated and expensive.

Read et al. (1974) built a solar kiln at Griffith, Australia. The kiln has approximately 600 ft^2 of solar collector inclined 38° to the horizontal. The collectors had a single glass glazing, and chemically applied, spectrally selected blackbody coating. Kiln capacity was 1,200 bd-ft and the S/L[2] ratio was 0.50ft^2/bd-ft. Air was circulated in the kiln by two 30-inch fans and through the solar collector by a small centrifugal fan. A rock pile thermal storage bed that provided about 16 hours of heat recovery per day was located under the kiln. Alpine ash lumber dried to 16 percent MC[3] in 20 days while a matched pile air-dried to only 42 percent MC in the same period.

Tschernitz and Simpson (1977) of the U.S. Forest Products Laboratory conducted a study to determine the feasibility of utilizing solar energy for lumber drying in developing countries. They indicated that the greenhouse-type kiln would not have the drying capacity to meet the necessary production rates when drying green lumber. They built a kiln which utilized an external collector horizontally oriented in which air was circulated. The absorbing surface was charcoal-covered soil, which provided some heat storage capacity. This kiln has about 4,000 bd-ft capacity and the S/L ratio was 0.24 ft^2/bd-ft. Initial run indicated that red oak could be dried in Madison, Wisconsin from 60 percent to 10 percent MC in 28 days during the summer.

The solar kiln at Virginia Polytechnic Institute (Oliveira, 1979) is actually a semi-greenhouse type, having a capacity of 150 bd-ft and provided with a 20-inch circulating fan. The kiln has the advantage of being insulated in all walls except the south wall, in order to minimize heat loss. Both the south-facing vertical wall and the south-facing sloping roof (45°) were double glazed with transparent polyester film. All other walls and the floors were insulated frame construction. Solar drying of oak from about 80 percent to 30 percent MC took 9 weeks in the spring, which was three-fourths as much time as air drying. Both the rates of drying and the final quality of the solar-dried lumber were superior to those of the air-dried lumber.

A solar kiln built by the U.S. Forest Service in Carbondale, Illinois (Chen and Rosen, 1979) used recycled aluminum beverage cans for the collector plate and a double-paned Fiberglas cover. The drying chamber was insulated. Air was circulated with a reversible and variable-speed fan.

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[2] S/L ratio refers to ratio of solar collector glazing area to lumber capacity.

[3] MC refers to moisture content of wood based on oven-dry conditions.

The relative humidity inside the kiln was controlled so that any excess moisture could be vented out. Yellow poplar was reported to be effectively dried in all seasons of the year 2 to 3.5 times faster by solar kiln drying than by air drying, but the drying rate in the kiln was initially slower. This kiln was later modified to include a dehumidifying system (Chen et al., 1980), and preliminary results indicate that yellow poplar could be dried faster and to a lower moisture content than by either solar or dehumidification drying alone.

Climate of Louisiana

Any study into utilization of solar energy requires appropriate climatic data for accurate engineering design specifications. For solar drying, the appropriate parameters are temperature, relative humidity, and insolation. Rainfall is indirectly important because of its effect on the other three. Unfortunately, obtaining specific design values for these variables is difficult because of considerable diurnal, seasonal, and geographic fluctuations.

A subtropical latitude and abundance of water bodies are the major determining factors of Louisiana's climate. Prevailing winds are southerly during the summer providing warm, moist air and frequent afternoon thunderstorms. During the winter, warm southerly winds alternate with cold continental air masses to produce varying length cycles which typically contain a period of rain with dropping temperatures, a period of cold, crisp days, and then a slow warming trend until the cycle is repeated.

Temperature

According to the National Oceanic and Atmospheric Administration (NOAA, 1976), the average annual temperature ranges from 66°F to 69°F in Louisiana. Average January and July temperatures are 49°F and 83°F in the northwest and 57°F and 81°F in the southeast, respectively. The cooler summer temperatures in the southern parts are due to the cooling effect of almost daily showers in the parishes near the Gulf. The number of days with freezing temperatures ranges from 24 at Shreveport to 4 at New Orleans.

Rainfall

Additional NOAA (1978) data indicate mean annual precipitation ranges from 46 inches in Caddo Parish to as much as 66 inches near the Gulf coastal areas. During the summer months, rainfall is highest in the southern portions of the state with almost daily showers in the coastal parishes. During the winter months, the northern parishes receive more rainfall because of cold air masses that stall and produce heavy rainfall where the cold continental air and the warm Gulf air meet. Showers and thunderstorms occur on an average of 50 to 60 days a year in the northwest and north-central areas, 60 to 70 days in central and northeast areas, and 70 to 80 days in south Louisiana. During fall, winter, and early spring, thunderstorms may occur any time of the day, but from late spring through summer most of the thunderstorms take place in the afternoon.

Solar Insolation

Unfortunately, insolation records, the most important data for solar energy research, are lacking. Daily insolation was measured prior to 1957 at the New Orleans weather station for 16 years, at the Lake Charles weather station for 11 years and the Shreveport weather station for 4 years. Monthly summaries are given in Table 1. The data indicate substantial differences among the cities, but there is insufficient data to develop a model to explain the source of this variability. Mean percentage of possible sunshine and mean number of hours of sunshine, two variables that affect solar insolation, are given for New Orleans and Shreveport in Table 2.

Table 1.—Mean daily solar radiation, by month, for three cities in Louisiana

Month	Solar radiation		
	Lake Charles	New Orleans	Shreveport
	....	(Langleys)[1]	....
January	245	214	232
February	306	259	292
March	397	335	384
April	481	412	446
May	555	449	558
June	591	443	557
July	526	417	578
August	511	416	528
September	449	383	414
October	402	357	354
November	300	278	254
December	250	198	205
Average	418	347	400

Source: U.S. Climatic Atlas. U.S. Dept. Commerce (1968).

[1] Langleys (Cal/cm^2) = 3.687 Btu/ft^2

Table 2.—Mean percentage of possible sunshine and mean number of hours of sunshine, by month, for two cities in Louisiana

Month	Sunshine			
	New Orleans		Shreveport	
	(%)	(Hrs)	(%)	(Hrs)
January	49	160	48	151
February	50	158	54	172
March	57	213	58	214
April	63	247	60	240
May	66	292	69	298
June	64	287	78	332
July	58	260	79	339
August	60	269	80	322
September	64	241	79	289
October	70	260	77	273
November	60	200	65	208
December	46	157	60	177
Average	59	228	69	251

Source: U.S. Climatic Atlas. U.S. Dept. Commerce (1968).

Climatic Patterns

Mean monthly climatic parameters at 3-hour intervals for four Louisiana weather stations were obtained (NOAA, 1978) to analyze Louisiana's climatic patterns. The National Weather Service Stations at Baton Rouge, Lake Charles, Shreveport, and New Orleans were chosen to achieve a geographic cross section of the state. Data were collected on five variables from January 1973 to August 1978. The five variables were cloud cover, temperature, wet-bulb temperature, relative humidity, and wind speed. Additionally, equivalent equilibrium moisture content (EMC) of wood was computed from the temperature and relative humidity data for each observation. Observations were at 3-hour intervals.

The statistics from 2,208 observations are given below:

	Mean	Standard deviation	Range
Dry bulb temperature (°F)	66.6	13.1	30.0- 96.0
Wet bulb temperature (°F)	61.4	11.5	29.0- 80.0
Relative humidity (%)	75.3	12.9	41.0-100.0
Equivalent EMC of wood (%)	15.3	4.0	5.4- 28.4
Cloud cover (1/10's)	5.5	1.4	1.0- 9.0
Wind speed (mph)	8.0	2.7	0.4- 16.9

Analysis of variance indicated that city, month, and time of day have highly significant effects on these variables. Figure 1 shows mean monthly temperature, humidity, and EMC for the four cities. The mean monthly climatic parameters at 3-hour intervals are presented in Table 3.

Materials and Methods

Solar Kiln Prototype

Wengert (1971) established the following energy use distribution for a greenhouse kiln at Fort Collins, Colorado:

	%
Conducted through north wall	1.5
Conducted through floor	11.4
Convection, roof and walls	29.1
Storage inside drier	7.4
Solar, outgoing	17.5
Longwave heat	13.2
Ventilation	14.4
Water evaporation (latent heat)	15.4

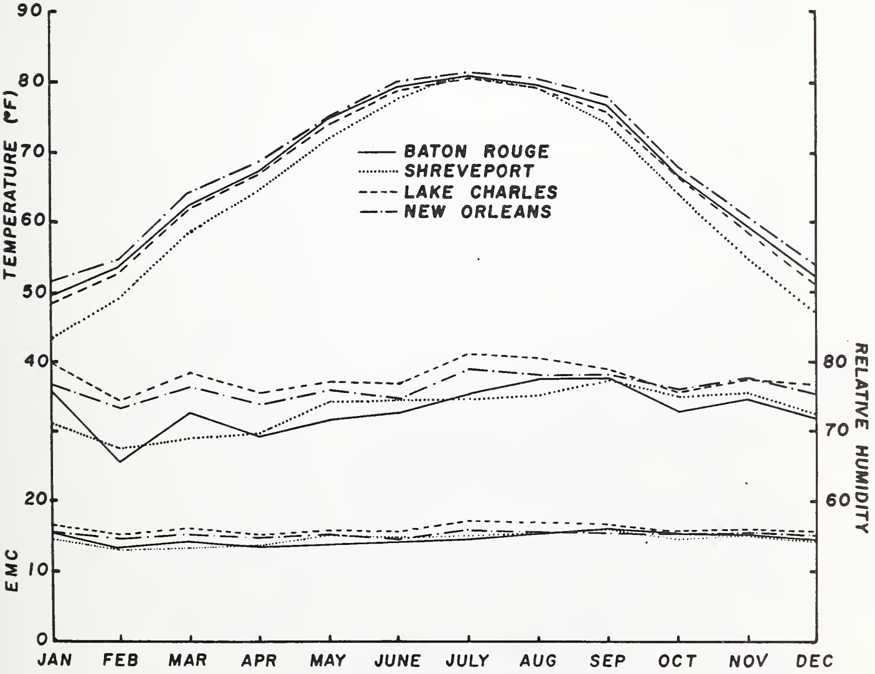

Figure 1.—Mean monthly temperature, relative humidity, and equivalent equilibrium moisture content of wood in four Louisiana cities.

Table 3.—Mean yearly climatic parameters at 3-hour intervals

Time	Temperature	Wet-bulb temperature	Relative humidity	EMC[1]	Cloud cover	Wind speed
	(°F)	(°F)	(%)	(%)	(1/10's)	(mph)
Midnight	62.6	59.8	84.6	18.0	4.6	6.6
3:00 AM	60.8	58.7	87.4	19.4	4.9	6.0
6:00 AM	59.9	58.0	88.3	19.9	5.6	5.9
9:00 AM	67.3	62.1	75.0	14.5	5.8	9.2
Noon	73.2	64.3	61.6	11.2	6.0	10.2
3:00 PM	74.6	64.5	58.2	10.5	6.0	10.5
6:00 PM	69.9	62.9	67.3	12.6	5.6	8.4
9:00 PM	64.7	61.0	80.0	16.2	4.9	6.9

[1] EMC refers to moisture content of wood in equilibrium with atmosphere.

Only 15.4 percent of the incoming energy was used for the intended purpose of drying wood. Conduction and convection accounted for the largest energy losses (42 percent) and were associated with the low thermal insulation characteristics of greenhouse kilns. Radiant losses of 30.7 percent were associated with the transparent walls of the drying chamber. These heavy losses seemed inefficient, so a kiln with external solar collectors was designed.

Drying Chamber

Theoretical Considerations—Use of an external solar collector allows isolation of the drying chamber from convective and radiant heat losses. Of course, the chamber must be well-insulated and opaque. The negative aspects are the additional expense and possibility of heat losses in the ducting system. Using the collectors as structural surfaces (but keeping them thermally isolated from the drying chamber) will tend to lower the heat losses but tend to constrain the size and orientation of the collectors.

Heat losses during venting cause no serious operational problems in a conventional kiln as the incoming air can be easily conditioned to the proper temperature and humidity. Such losses, however, cost money. In a solar kiln these heat losses may create problems as the energy source is limited and reheating incoming air by solar means may be difficult. Computer simulation showed that losses in venting may involve as much as 25 percent of the heat required for a solar kiln, particularly in regions with high humidities or low temperatures. Additionally, venting at night cools down the lumber pile, preventing a buildup of thermal inertia. However, due to diurnal temperature fluctuations of a solar collector, the possibility of water removal by condensation exists. This would eliminate the need for venting, providing the following advantages: (1) heat loss from venting the kiln would be saved, and part of the heat of vaporization might be recovered as moisture condenses; (2) reduction of heat losses at night would allow the kiln to maintain higher average temperatures; (3) as drying progressed and less water was removed from the wood, the relative humidity of the kiln would automatically decrease.

Isolation of the drying chamber leads to an interesting possibility for solar heat storage—the wood pile. The specific heat of dry wood (c_0) is $c_0 = 0.25 + 0.0006(t)$, where t is temperature (°F). The specific heat (c) of wet wood is given by

$$c = \frac{m+c_0}{1+m} + A$$

where m is the fractional moisture content of the wood and A is the increases in specific heat due to wood-water bond energy—it ranges from

0.04 at 85°F to 0.09 at 140°F (U.S. Forest Products Lab., 1974). A comparison of heat storage capacity for wood (assuming a specific gravity of 0.56 and wood temperature of 100°F) at several moisture contents with other sensible heat storage media is shown below:

Material	Density (D)	Specific heat (c)	Volume heat capacity (D.c)
	(lbs/ft³)	(Btu/lb-°F)	(Btu/ft³-°F)
Water	62.43	1.00	62.43
Iron shot	490.68	0.13	63.79
Rock	156.07	0.20	31.21
Wood (20% MC)	41.90	0.53	22.14
Wood (60% MC)	55.90	0.64	35.71
Wood (120% MC)	76.90	0.89	68.30

Rock is probably the most common heat storage medium for solar air systems because of its relatively high heat storage capacity and low cost. Wood, particularly wet wood, is competitive in heat storage capacity, especially when considering the large wood volume already present in a large lumber kiln. Using the lumber pile as heat storage would eliminate the expense and complication of an external storage system.

Relying on the wood pile for heat storage will, however, result in less stable temperature conditions than could be obtained with an external storage system because the wood can only moderate diurnal temperature fluctuations. An external heat storage system would moderate the diurnal temperature fluctuations outside the kiln thus allowing the drying chamber to maintain average conditions. Maintaining constant wood temperature, however, is not the most important consideration—effectively utilizing the captured heat is. If the drying chamber is thermally isolated at night, the only loss of heat energy from the wood would be due to evaporative cooling. The stored heat would therefore promote drying by increasing evaporation (above fiber saturation point) or accelerating bound water diffusion (below fiber saturation point).

Implementation—The experimental solar kiln built at Louisiana State University was fitted into an existing 8-ft by 8-ft by 12-ft concrete blockhouse with a poured concrete foundation and prestressed concrete roof. A 6-ft by 6-ft by 4-ft drying chamber was built on the inside of the blockhouse. The walls, floor, and ceiling of the chamber consisted of 4 inches of (K-13) cellulose fiber insulation, a polyethylene vapor barrier, and 1/3 inch epoxy-coated, tempered hardboard. A 24-inch high-volume axial fan powered by a 1½ horsepower motor provided air circulation through a 34-inch by 34-inch by 6-foot lumber pile (approximately 360 bd-ft 8/4 lumber) using 1-inch stickers. Two 12-inch ducts led to a solar collector mounted on the roof.

Evaporative moisture from wood was used to provide humidification in the system, which is necessary in the initial drying of refractory hardwoods to prevent excessive degrade. Moisture in the kiln was removed as condensate through drain holes on the bottom of the kiln and during periodic moisture content measurements when the kiln door was opened.

Box-Type Solar Collector

Theoretical Considerations—Standard flat-plate collectors seem to have three limitations in solar kiln design.[4] One is that optimum collector orientation does not coincide with traditional geometrical configurations of dry kilns. Secondly, a flat-plate collector with the same surface area as a conventional kiln could not possibly supply the necessary heat. Finally, seasonal variations in the sun's altitude cause under-utilization of a fixed-position flat-plate collector at certain times of the year.

To overcome these difficulties, a "box-type" solar collector was envisioned. This collector resembles a large box cut diagonally through opposite corners (Figure 2). The three walls and floor of the box serve as heat collecting surface, and the diagonal plane is the solar glazing. Although no mention of this configuration was found in the literature, it seems to have some conceptual advantages over a flat-plate collector. First, the solar absorption area is increased more than 100 percent over that of a standard flat-plate collector with the same amount of glazing.[5] This results in more heat transfer surface and more potential for collection of diffuse solar radiation. Second, radiation from varying angles during different seasons or times of the day will be more nearly perpendicular to one of the four absorbing surfaces in a box collector than it could be to a stationary flat plate. As shown in Figure 3a, winter sun rays are nearly perpendicular to the vertical surface while summer rays are perpendicular, or normal, to the horizontal surface. Likewise, early morning or late afternoon sunshine will be nearly perpendicular to the east- or west-facing plane. Normality of radiation to collecting surface results in higher absorbance. Part of the energy striking a flat-plate collector is reflected back to the atmosphere. The box collector's geometry, as shown in Figure 3b, will usually allow

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[4] A preliminary study of solar drying was made using a flat-plate solar collector as the heat source. The results from drying elm, hackberry, sweetgum, and sycamore have been published by Lumley and Choong (1979).

[5] It is recognized that the amount of solar energy that strikes the collector glazing area determines the gross energy input into the collector system. The glazing area becomes a critical factor in a flat-plate collector if the absorbance is better than 90 percent efficiency. However, when collector efficiency is less, as is the case with a low-cost system, reflectance off the absorber panel becomes important.

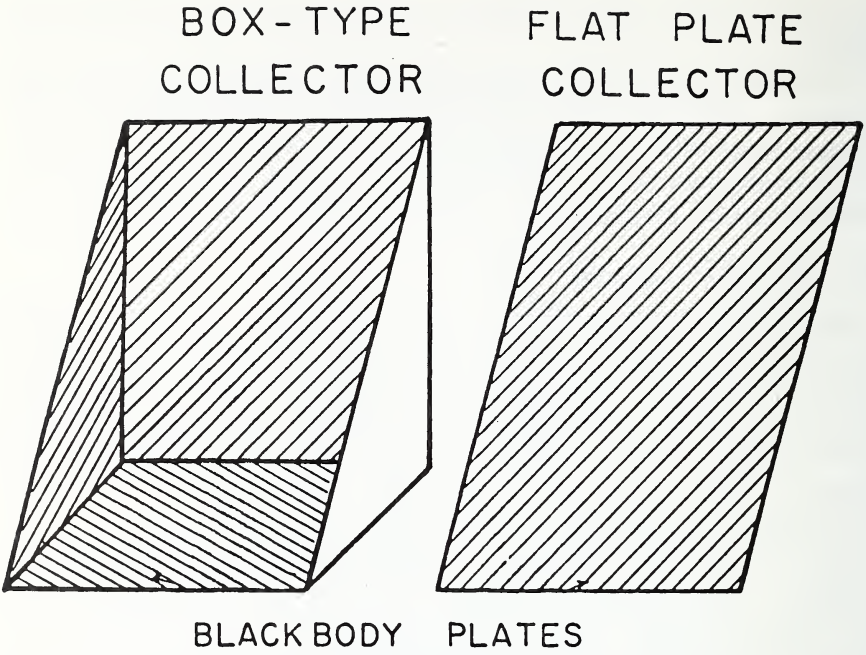

Figure 2.—Comparison of box-type solar collector with a standard flat-plate collector.

reflected radiation to strike another absorbing surface before being reflected back toward space. Finally as shown by Lumley and Choong (1979) the box-type collector can be integrated into a solar kiln structure.

An interesting aspect of the box collector is that manipulation of the dimensions of the glazing[6] or angle at which the glazing is inclined significantly affect the size and orientation of the blackbody. Small glazing angles tend to have large horizontal but small vertical collection surfaces, whereas large glazing angles tend toward large vertical areas with small horizontal ones. Manipulation of the glazing angle will therefore allow flexibility for establishing seasonal collection priorities. For instance, to increase winter heat collection, the glazing angle is increased, enlarging the area of vertical blackbody which is more normal to winter insolation.

Altering the length (inclined edge of glazing) and width (horizontal edge of glazing) of the solar glazing affects width and the blackbody area. The area of horizontal and vertical blackbody can be shown mathematically to be equal for the two orientations, but the amount of east- and west-facing collector area increases as width is decreased and length of the glazing is increased. Shadows, of course, play an important part in this collector's performance. A point will be reached where the increase in surface area is offset by losses due to shading.

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[6] Glazing is a thin layer of material (e.g. glass, plastic, etc.) that allows passage of short wave radiation from the sun.

Implementation—The box collector used on the experimental solar kiln

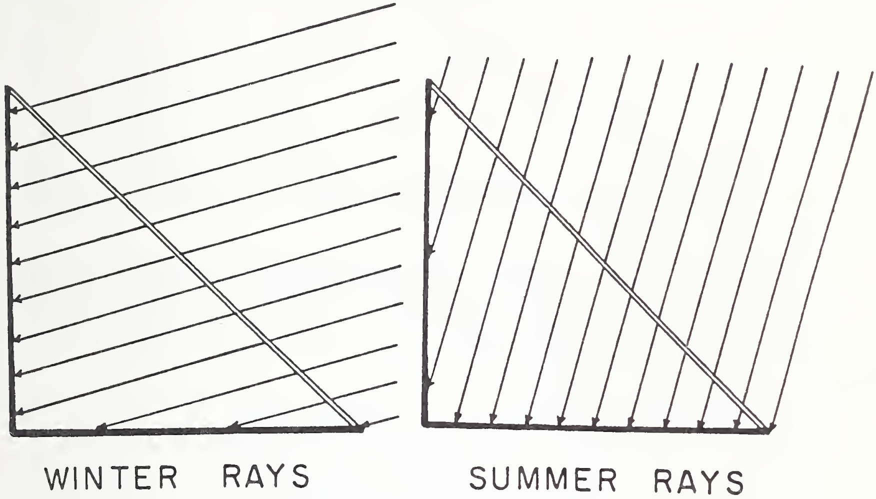

Figure 3a.—Incident angle of solar radiation during two seasons. The perpendicular collecting surfaces allow constant interception of solar radiation in all seasons.

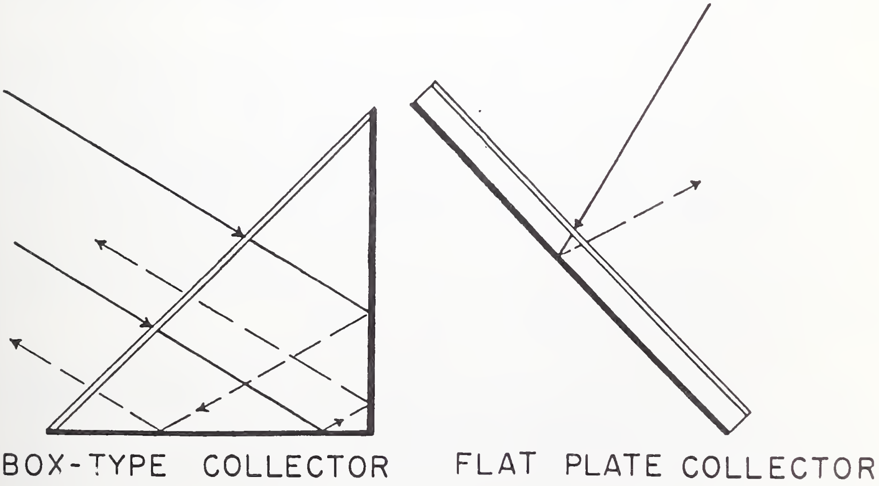

Figure 3b.—Comparison of reflected radiant losses for two collector configurations. The box-type collector allows reflected radiation a second chance to be absorbed by another collector surface.

has a 3.5-ft wide by 7.5-ft long (26.25 ft^2) sheet of (Kalwall Sun-Lite Premium II) fiberglass reinforced polyester glazing inclined at a 49° glazing angle. The ratio of solar glazing area to lumber volume is approximately 0.073 ft^2/bd-ft.

To arrive at the optimal glazing angle, a computer model was developed. While holding the size of the collector glazing constant, the area of horizontal, vertical, east-, and west-facing collector surfaces were computed for hypothetical boxes varying by one degree in glazing angle. After correcting for the effect of internal shadows, Kusuda and Ishii's (1977) tabulation of solar radiation data for various surfaces was used to integrate hourly heat collection over a 1-year period for the various collector configurations. The simulation showed that maximum year-round heat would be provided by the 49° pitch.

A cross-sectional view of the solar kiln (Figure 4) shows the solar collector is connected to the drying chamber by two vents running through the roof. At night the vents to the solar collector are closed, and air circulates within the drying chamber.

Several controlling and recording instruments were used in the solar drying project to provide automatic control of kiln operation and continuous monitoring of drying conditions. The dampers on vents leading to the solar collector are actuated by two (Honeywell Modutrol) electric damper motors. The damper motors are activated by a (Hawthorn) differential thermostat that compares solar collector temperature to drying chamber temperature and opens the vents when the positive temperature differential exceeds approximately 20°F.

A mist humidifier was installed in the kiln to provide control over humidity conditions. The humidifier could be manually operated, or controlled by a (Hygrodynamics) humidity controller at any set RH condition. The humidification system was never used, however, as the kiln's relative humidity remained at appropriately high levels from the moisture content in the wood during the initial stages of drying. Kiln humidity was monitored by a (Honeywell) electronic wet-bulb/dry-bulb circular chart (12 inch) recorder. The psychrometer assembly was placed on the outgoing-air side of the lumber pile.

A (Honeywell) thermocouple temperature recorder measured temperature at various points inside the kiln and solar collector. External ambient temperature was also measured. Type K thermocouples (iron/constantan) were used with the recorder which was calibrated for a temperature range of 0°F to 500°F. The instrument was sensitive to ±1°F. Outside relative humidity was monitored by a (Honeywell) mechanical circular (8 inch) chart recorder. A (Li-Cor LI-550) printing solar insolation integrator measured daily solar radiation.

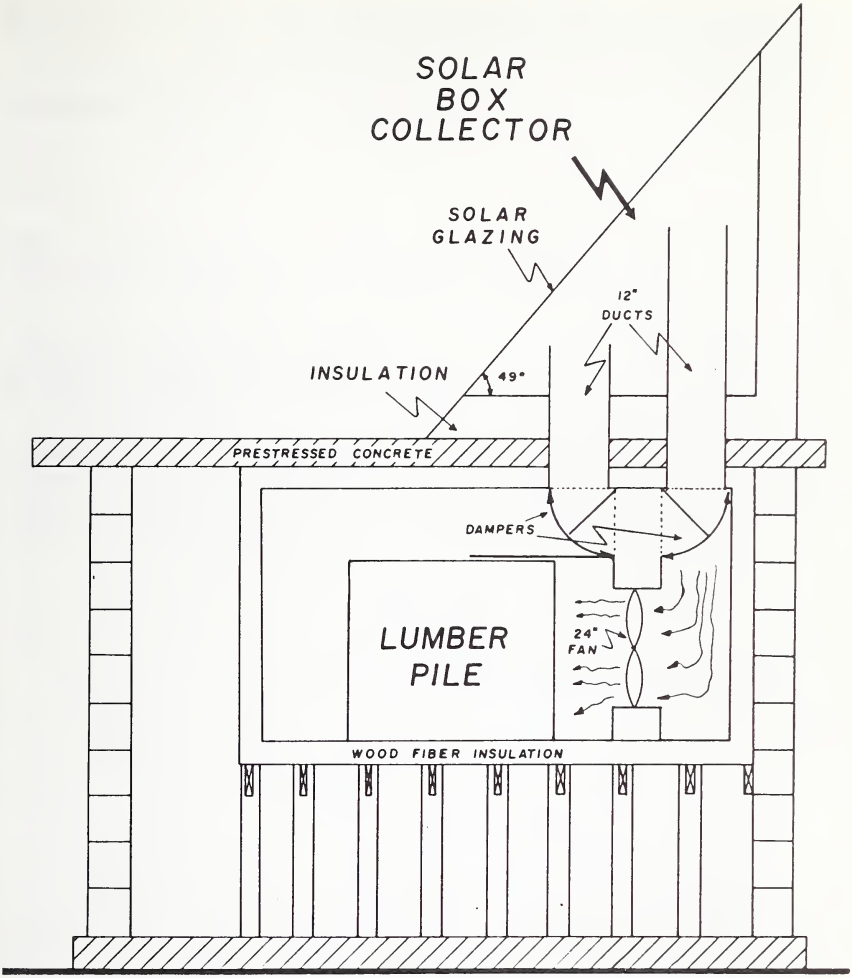

Figure 4.—Cross-sectional view of experimental solar lumber kiln.

Experimental Design

Sampling Design

Six loads of lumber were dried in the experimental solar-heated kiln. They were, in chronological order, 8/4 ash, 8/4 hackberry, 6/4 red oak, 4/4 ash, 4/4 cypress, and 6/4 red oak. Each load consisted of at least 44 6-ft boards, mostly 8 inches wide. Loads of 1-inch lumber had more samples to fill the kiln's capacity. Lumber was obtained green from a local sawmill in 12-ft lengths, cut in half to 6 ft, and end-coated with a commercial sealer.

Four or five 6-ft sections (depending on width) were cut into 2-ft sections to provide kiln samples and matched air drying samples as shown in Figure 5. These samples were also end-coated. A moisture content section was cut from between the air and kiln samples to estimate initial moisture content. The lumber was undressed No. 2 or No. 3 common grade.

Data Collection and Analysis

Data collected for the drying experiments can be grouped into four categories: (1) drying conditions, (2) drying rate, (3) drying charge, and (4) climatic conditions.

Drying Conditions—Kiln drying conditions are determined by temperature, relative humidity, and air velocity. Air velocity was held constant at approximately 400-500 fpm and therefore was not a variable factor. Dry-bulb and wet-bulb temperatures were recorded at 1-hour intervals and transferred to computer cards. Blackbody temperature, ambient temperature, and ambient relative humidity were also coded on the cards at 1-hour intervals. Relative humidity and equilibrium moisture content are normally determined with use of tables or psychromatic charts. This method is quite adequate with the steady-state drying conditions found in most dry kilns, but it is too cumbersome for the constantly fluctuating conditions of a solar kiln. A computerized computational method was therefore designed.

Drying Rate—Four or five matched air and solar kiln samples were weighed on a (Pennsylvania Scale Co.) weighing balance (accurate to 0.01 lb) each morning, except on weekends and holidays, to determine drying rates. After drying was complete, these samples were ovendried so that the exact moisture contents could be calculated and a drying curve determined.

Drying Charge—Each of the 6-ft boards was weighed before and after drying. A (Delmhorst) resistance moisture meter was used to estimate the final moisture content by averaging observations from several measurements on each board. Moisture meter prongs were driven approximately

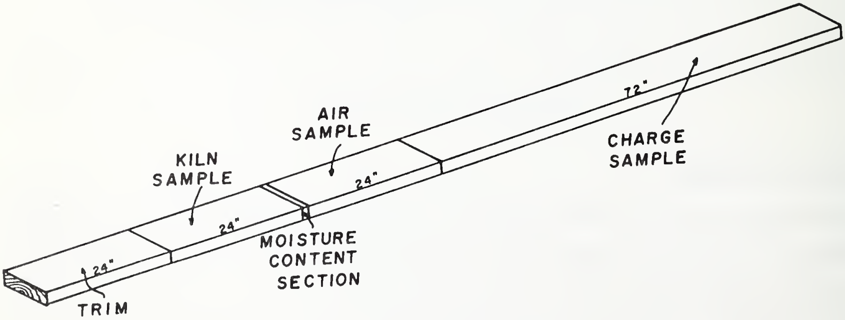

Figure 5.—Sample preparation for kiln, air, and charge samples.

halfway into the boards. After drying, each board was also evaluated for drying defects. Warp was determined by measuring maximum bow, crook, twist, and cup to the nearest 1/32 inch. Bow and crook were measured by placing each end against an 8-ft steel straightedge and determining the maximum distance from the straight edge to the wood surface. Twist was determined by holding three corners against a plane surface and measuring the elevation of the fourth corner. Cup was measured by placing a 12-inch, plastic triangle across the face of the board and measuring maximum deviation. The total number of surface checks, end checks, and end splits was counted on each board. Any indications of honeycombing or collapse were noted, and several boards from each charge were tested for case-hardening (Rasmussen 1961).

Climatic Data—Daily solar radiation and hourly ambient temperature and humidity conditions were monitored just outside the solar kiln. Additionally, sky cover, temperature, wet-bulb temperature, relative humidity, and wind speed data at 3-hour intervals were obtained from the National Weather Service Station at Ryan Airport in Baton Rouge.

Results

The solar kiln was tested with six charges of wood between March, 1978 and January, 1979. Drying data was collected for all four seasons, and all 12 months except February, July, and September. The kiln was tested under optimal as well as poor climatic conditions. Table 4 summarizes the kiln and external ambient drying conditions during the experiment. Overall, the kiln maintained an average temperature of 97.6°F which was 30.5°F over average ambient of 67.1°F. The average volume of lumber dried was approximately 300 bd-ft, making the average S/L ratio equal to 0.088 ft^2/bd-ft. Solar- and air-drying times of each load to various moisture contents are given in Table 5.

The quality of the seasoned lumber from all six loads is summarized in Table 6. The average green moisture content of these 294 boards was 73.6 percent; the average moisture content after seasoning was 10.8 percent. Bow, crook, and twist of the boards averaged less than 1 percent of length, and cup averaged 1.3 percent of width. The average board had 3.1 surface checks and less than one end check or end split. Analysis of variance showed species to be the most significant independent variable in the analysis, but pith location was also a large source of drying defects, especially checking and splitting (Table 7).

Drying Charge 1 (8/4 Ash)

Kiln and ambient temperature and relative humidity parameters during the drying period are shown in Table 8, and graphically presented in Figure

Table 4.—Summary of climatic conditions inside and outside of solar kiln

Drying period	Lumber	Volume	S/L Ratio[1]	Mean temperature			Mean rel. humidity		EMC
				Kiln	Ambient	Diff.	Kiln	Ambient	
		(Bd-ft)		......	(°F)	....	...... (%)	......	(%)
3/22 - 4/10/78	8/4 Ash	360	.073	102.3	66.0	36.3	53.6	68.5	9.3
4/22 - 5/12/78	8/4 Hackberry	352	.075	103.5	72.0	31.5	--[2]	71.7	--[2]
5/18 - 6/16/78	6/4 Red oak	265	.099	114.2	79.4	34.8	41.3	77.3	7.1
8/3 - 8/23/78	4/4 Ash	270	.097	110.7	85.9	24.8	54.5	78.7	9.6
10/6 - 10/27/78	4/4 Cypress	265	.099	96.4	67.6	28.8	55.5	70.5	10.4
11/11/78 - 1/11/79	6/4 Red oak	265	.099	82.2	53.8	28.4	63.0	61.4	12.3
Average:		297	.088	97.6	67.1	30.5	44.5	74.5	12.6

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[1] Ratio of solar collector glazing area to lumber capacity.

[2] Data missing due to instrument failure.

Table 5.—Solar and air drying times to reach certain moisture contents (MC) for various species

Lumber	Drying period	Initial MC	Drying time Solar 30%MC	Drying time Solar 20%MC	Drying time Solar 15%MC	Drying time Air 30%MC	Drying time Air 20%MC
		(%)	(Days)				
8/4 Ash	3/22 - 4/10/78	51	6	13	18	16	(47)[1]
8/4 Hackberry	4/22 - 5/12/78	81	10	15	19	24	(50)[2]
6/4 Red oak	5/18 - 6/16/78	82	16	25	29	51	(104)[3]
4/4 Ash	8/3 - 8/23/78	50	3	6	9	7	22
4/4 Cypress	10/6 - 10/27/78	89	8	12	14	16	27
4/4 So. pine		160	6	7	8	12	23
6/4 Red oak	11/11/78 - 1/11/79	92	35	55	(66)[4]	112	--
4/4 So. pine		111	9	11	15	25	43

[1] Estimated by extrapolation. Drying stopped at 22% MC after 41 days.
[2] Estimated by extrapolation. Drying stopped at 22% MC after 45 days.
[3] Estimated by extrapolation. Drying stopped at 23% MC after 88 days.
[4] Estimated by extrapolation. Drying stopped at 17% MC after 62 days.

Table 6.—Summary of characteristics of lumber quality for all drying charges

Characteristic	Species[1]						Overall
	Ash	Hack-berry	Red oak	Ash	Cypress	Red oak	
Thickness (inch)	8/4	8/4	6/4	4/4	4/4	4/4	--
Green MC (%)	48.5	84.6	77.0	50.5	101.2	90.1	73.6
Dried MC (%)	12.3	13.6	15.4	6.8	7.2	14.1	10.8
Drying time (days)	19	20	29	20	21	62	28.5
Number of knots	6.8	6.4	15.1	3.4	3.8	3.0	5.9
Bow (1/32-inch)	6.7	12.4	5.9	5.6	4.5	4.4	6.4
Crook (1/32-inch)	6.8	13.8	4.5	6.6	5.5	9.0	7.4
Twist (1/32-inch)	5.8	6.0	2.9	5.5	6.6	14.2	6.7
Cup (1/32-inch)	2.1	5.3	5.7	1.7	2.2	4.4	3.3
Surface checks[2]	0.0	0.7	15.6	0.2	1.5	4.3	3.1
End checks[2]	0.5	0.4	4.6	0.0	0.0	0.7	0.9
End splits[2]	1.0	0.5	0.8	0.2	0.2	0.5	0.5

[1] All were No. 2 Common grade except 4/4 ash which was No. 3 Common.

[2] Based on total number of checks on each board.

Table 7.—Effect of position in kiln, pith location, knots, and species on moisture contents and drying defects in six kiln charges

Dependent variables	Independent variables				
	Row[1]	Column[2]	Pith location	No. of knots	Species
Green MC	NS	***	***	NS	***
Dried MC	***	NS	***	***	***
Bow	*	NS	NS	NS	***
Crook	***	NS	*	NS	***
Twist	***	NS	***	*	***
Cup	***	**	***	**	***
Surface checks	**	NS	***	***	***
End checks	***	NS	***	***	***
End splits	NS	NS	***	NS	NS

[1] Row refers to horizontal layers in the lumber pile. It is important to the extent that loading (weight) affects warping.

[2] Column refers to vertical layers in the lumber pile. It is important to the extent that relationship to the fan (heat source) affects drying rate.

NS = Not significant

*	$P < .05$
**	$P < .01$
***	$P < .001$

6. Average kiln temperature was 102°F and average relative humidity was 53.6 percent. The drying run indicated that the solar kiln performed very well. Its temperature was always above external ambient except during the first hours of operation, and the average humidity was lower than ambient. Weather was favorable during most of the drying period; there were many sunny days and average ambient temperature was slightly above normal.[7] As drying progressed kiln temperature showed a general upward trend due to thermal storage in the wood pile and less evaporative cooling by the lumber. Kiln and ambient temperatures both showed diurnal fluctuations, but the kiln had a lower coefficient of variation (9.6 vs. 16.2) indicating that it was more temperature stable than external ambient. Likewise, the relative humidity of the kiln (CV = 23.3) seemed to be more stable than that of the ambient humidity (CV = 27.9). The average temperature difference between kiln and ambient was 36.3°F. The average equilibrium moisture content of wood in the kiln was 9.3 percent, lower than could be

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[7] Normal as established by National Oceanic and Atmospheric Administration (1976).

Table 8.—Climatic properties inside and outside of solar kiln during Charge 1

Property	N[1]	Mean	Standard deviation	Range
Dry bulb kiln temp ($^{\circ}$F)	456	102.3	9.8	66.0 - 123.0
Wet bulb kiln temp ($^{\circ}$F)	456	86.4	9.3	64.0 - 106.0
Humidity inside kiln (%)	456	53.6	12.5	32.0 - 91.0
Equilibrium MC of wood (%)	456	9.3	2.8	6.1 - 20.7
Ambient temp ($^{\circ}$F), campus[2]	456	66.0	10.7	38.0 - 87.0
Ambient temp ($^{\circ}$F), airport[3]	151	65.2	10.4	39.0 - 83.0
Ambient humidity (%), airport	151	68.5	19.2	26.0 - 100.0
Temp difference (kiln-ambient, $^{\circ}$F)	456	36.3	8.7	-2.0 - 50.0
Blackbody temp ($^{\circ}$F)	456	85.1	23.7	44.0 - 144.0
Cloud cover (1/10's)	151	5.4	7.7	0.0 - 10.0
Wind speed (mph)	151	7.6	4.2	0.0 - 16.1

[1] N refers to number of measurements.
[2] Ambient temperature was measured outside the solar kiln.
[3] Ambient temperature was measured at the Greater Baton Rouge Airport.

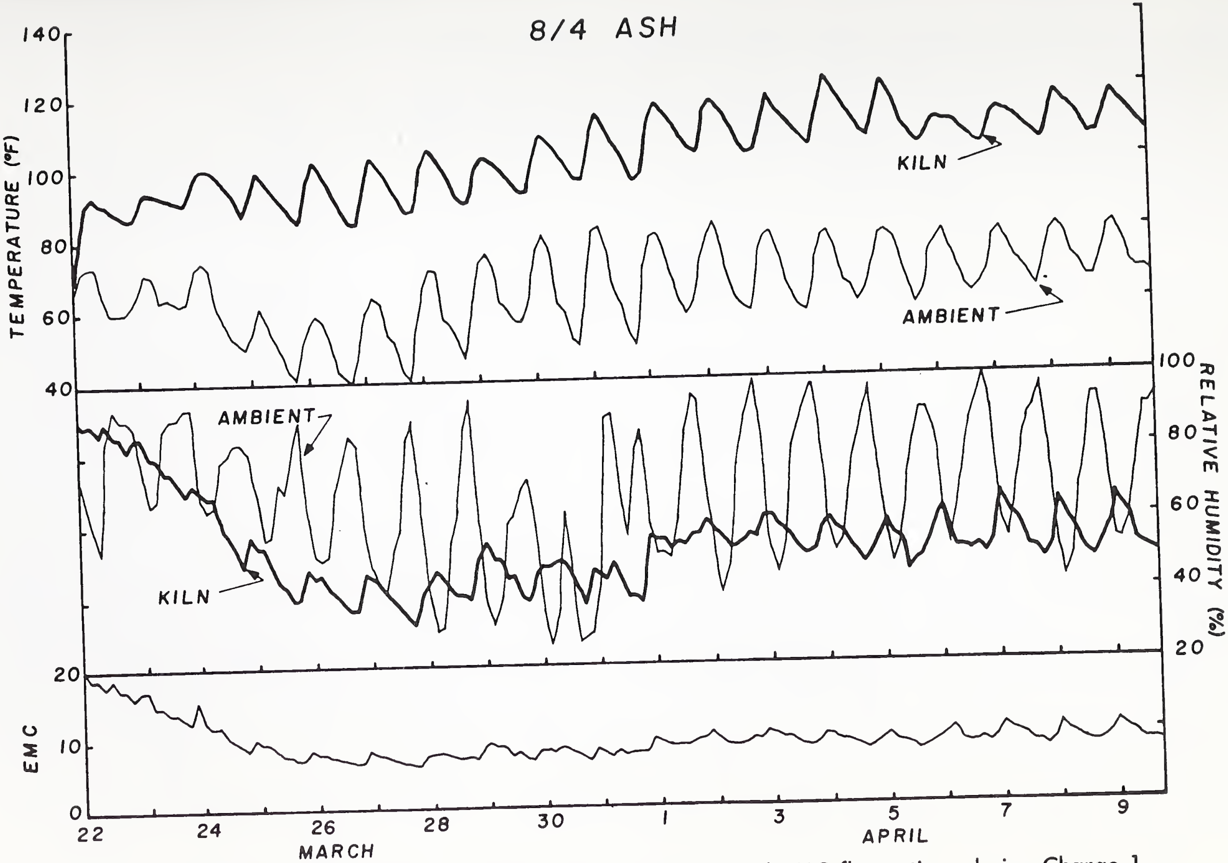

Figure 6.—Diurnal temperature, relative humidity, and EMC fluctuations during Charge 1.

expected in air drying.

The mean green moisture content of the kiln samples was 51.3 percent, while that of the air samples was 47.6 percent. In comparison with air drying, the kiln samples dried at a much faster rate, especially in the latter stages, and reached a lower final moisture content. As shown in Figure 7, the kiln samples dried from a mean 51.3 percent MC to 14.4 percent in 19 days. whereas the air samples dried to 29.6 percent MC in 19 days and to 22.3 percent in 40 days. The drying rates slowed down considerably during the latter stages so the load was removed from the kiln. The lumber could have been finished efficiently in a standard dry kiln faster since it had dried to the point where it could have tolerated more drastic drying conditions.

The drying characteristics of the boards are summarized in Table 9. The mean moisture content after drying was 12.3 percent, with a standard deviation of 1.21. The dried moisture contents of the kiln samples were not significantly different. The lower coefficient of variation for dried moisture content, as compared with the green moisture content (9.9 vs. 14.0, respectively), indicates convergence toward an equilibrium during drying. Analysis of variance showed that pith location, used as an indicator for lumber quality, significantly affected drying degrade (Table 10). Large knots seemed to be associated with much of the warping defect. This was, however, not detected by analysis of variance, possibly because the data did not consider the size of knots but only the number of knots shown on both faces. No evidence of collapse or honeycombing was noticeable in any of the boards. Slight case-hardening was detected, but the data were not subjected to numerical analysis. Bow, crook, and twist averaged 0.29, 0.30, and 0.25 percent of length, respectively. Cup averaged 0.82 percent of width. The significant effects of pith location on crook, cup, twist, end checks, and surface checks could be expected from the low strength and lack of dimensional stability in juvenile wood.

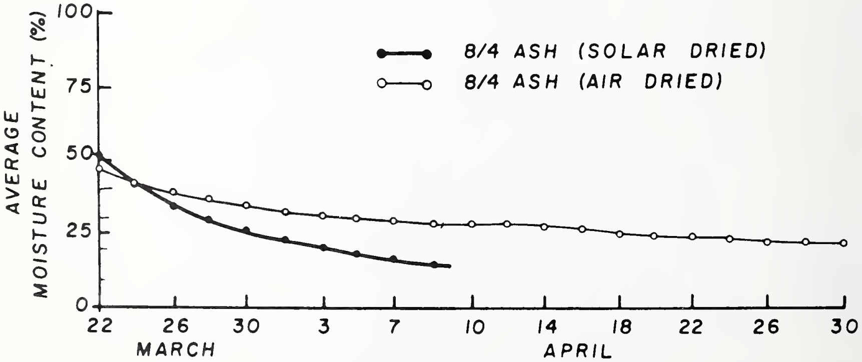

Figure 7.—Solar and air drying rates during Charge 1.

Table 9.—Characteristics of lumber quality in Charge 1 (8/4 No. 2 ash)

Characteristic	N	Mean	Standard deviation	Range
Green MC (%)	46	48.5	6.8	21.3 - 74.5
Dried MC (%)	46	12.3	1.2	6.5 - 14.1
Number of knots	46	6.8	3.3	0.0 - 17.0
Bow (1/32-inch)	46	6.7	3.2	2.0 - 16.0
Crook (1/32-inch)	46	6.8	3.9	0.0 - 16.0
Twist (1/32-inch)	46	5.8	4.1	0.0 - 16.0
Cup (1/32-inch)	46	2.1	1.1	0.0 - 5.0
Surface checks	46	0.0	0.0	0.0 - 0.0
End checks	46	0.5	0.9	0.0 - 3.0
End splits	46	1.0	1.2	0.0 - 4.0

Table 10.—Effect of position in kiln, pith location, and knots on moisture contents and drying defects of Charge 1

Dependent variables	Independent variables			
	Row	Column	Pith location	No. of knots
Green MC	NS	NS	NS	NS
Dried MC	*	NS	NS	NS
Bow	NS	NS	NS	NS
Crook	NS	*	*	NS
Twist	NS	NS	NS	NS
Cup	NS	NS	**	NS
Surface checks	--[1]	--	--	--
End checks	*	NS	**	NS
End splits	NS	NS	***	NS

[1] No surface checking was observed.

Differences in moisture contents among row positions in the kiln indicate some deficiencies in the air circulation system, especially since green moisture contents were not significantly different. Reversing the direction of air flow might minimize this effect.

Drying Charge 2 (8/4 Hackberry)

Failure of the electronic psychrometer assembly during this test limited interpretation of drying conditions because of the absence of relative humidity and equilibrium moisture content data. The average ambient temperature during the period was about normal. The mean kiln temperature was slightly higher (103.5°F) than the previous load (Table 11), but the average temperature difference (31.5°F) between kiln and ambient was lower, probably due to higher ambient temperatures, higher initial wood moisture content, and two periods of cloudy and rainy weather. These periods (May 3 and May 6-8), as indicated in Figure 8, had very high ambient relative humidity and lower-than-normal kiln temperature. It should be noted that the kiln maintained a temperature of 100°F or more during these periods with little or no solar heat input, which demonstrates the kiln's ability to store heat. Divergence from the normal pattern on April 23-24 was due to fan failure, resulting in high blackbody temperature of

Table 11.—Climatic properties inside and outside of solar kiln during Charge 2

Property	N	Mean	Standard deviation	Range
Dry bulb kiln temp (°F)	485	103.5	10.6	72.0 - 127.0
Wet bulb kiln temp (°F)	---[1]	--	--	-- --
Humidity inside kiln (%)	---[1]	--	--	-- --
Equilibrium MC of wood (%)	---[1]	--	--	-- --
Ambient temp (°F), campus	484	72.0	8.7	50.0 - 92.0
Ambient temp (°F), airport	162	70.7	8.4	49.0 - 86.0
Ambient humidity (%), airport	162	71.7	18.3	27.0 - 97.0
Temp difference (kiln-ambient, °F)	484	31.5	10.4	-6.0 - 50.0
Blackbody temp (°F)	484	99.5	20.7	57.0 - 210.0[2]
Cloud cover (1/10's)	162	5.9	4.3	0.0 - 10.0
Wind speed (mph)	162	9.6	4.4	0.0 - 23.0

[1] Data are not available due to failure of wet bulb sensing unit.
[2] Extreme value to to fan failure.

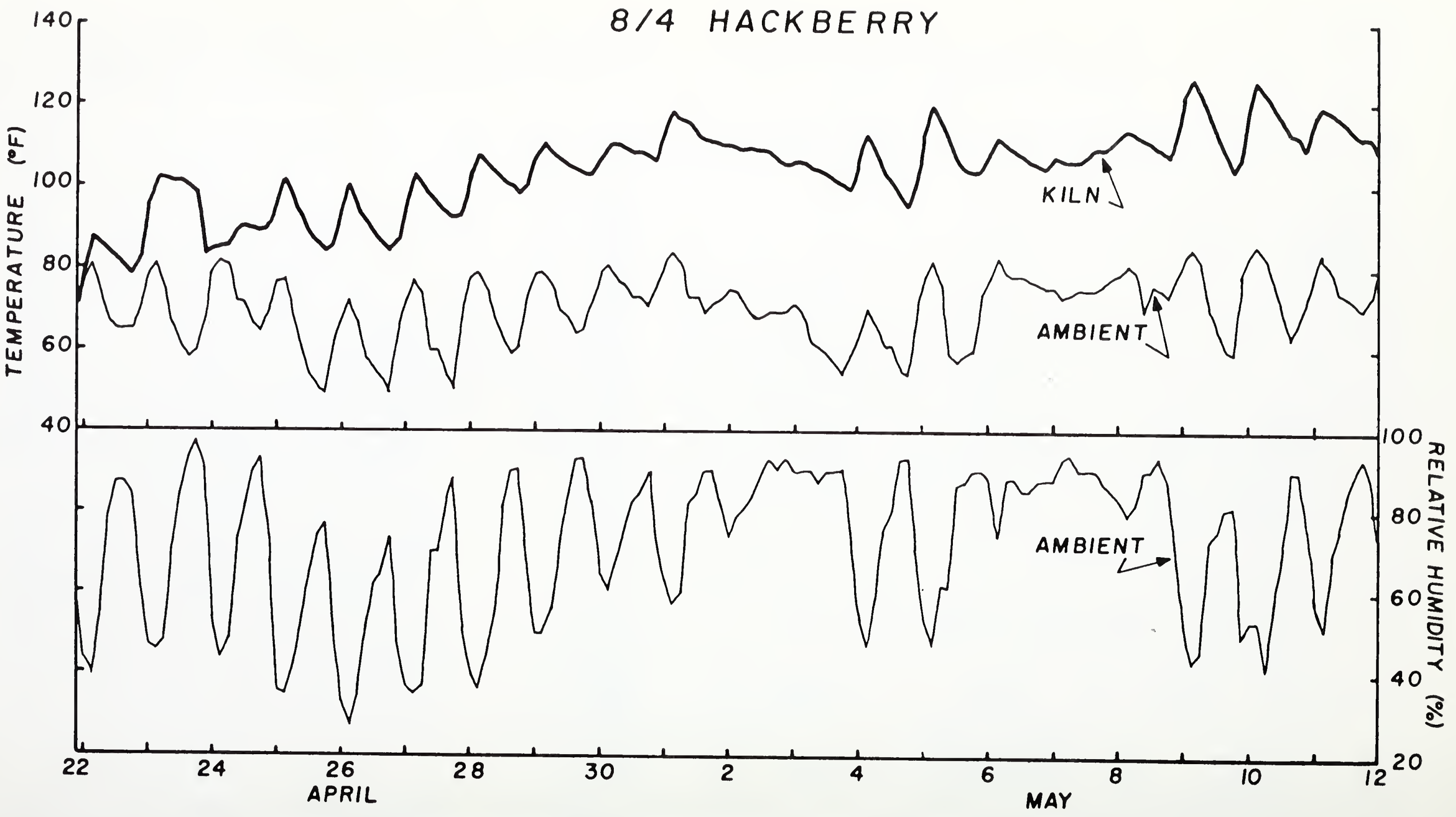

Figure 8.—Diurnal temperature and relative humidity fluctuations during Charge 2.

210.0°F. As in the previous load, a negative temperature difference between kiln and ambient (−6°F) occurred immediately after the kiln was loaded.

The average green moisture content of the kiln samples was 80.9 percent, whereas that of the air samples was 80.2 percent. Drying curves for solar and air drying, shown in Figure 9, indicate that it took 20 days for the kiln samples to dry from 81 percent to 13.5 percent MC, whereas the air samples reached only 33.6 percent MC during the same period.

The air samples dried faster than the kiln samples during the first 5 days but much slower after that, suggesting that there was insufficient potential for evaporation when high humidities were present in the initial kiln stages despite the increased temperature. To minimize this effect, one could partially dry high moisture content lumber to about 50 percent MC, which is the point where solar drying seemed to overtake air drying in hackberry. Another alternative may be to vent the solar kiln in the initial stages to increase evaporative capacity, especially if the wood is not refractory.

Drying characteristics of the load are summarized in Table 12. Analysis of variance showed twist was significantly affected by knots, and checking was related to pith location and kiln position (Table 13). Warping was about twice as severe as that of the previous load, despite the similar size and drying conditions of the boards. The reason may be due to hackberry's low dimensional stability. Mean bow, crook, and twist were 0.54, 0.60, and 0.26 percent of length, respectively. Average cupping was 2.07 percent of width. No evidence of collapse or honeycombing was noted, but some slight casehardening was detected.

The significant effect of pith location on checking could be expected for the same reasons outlined for the previous load. Cross grains in knots contribute to warping defects. The significant effect of column position in the kiln on surface checking may be related to proximity to the fan. The

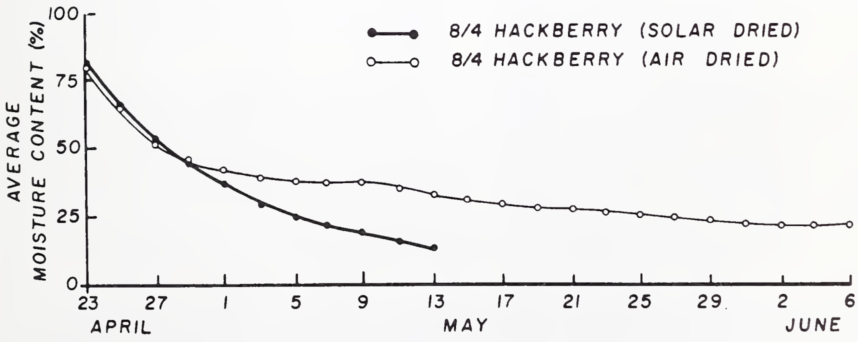

Figure 9.—Solar and air drying rates during Charge 2.

Table 12.—Characteristics of lumber quality in Charge 2 (8/4 No. 2 hackberry)

Characteristic	N	Mean	Standard deviation	Range
Green MC (%)	40	84.6	11.8	64.3 - 109.1
Dried MC (%)	40	13.6	2.5	8.5 - 17.8
Number of knots	40	6.4	4.9	0.0 - 17.0
Bow (1/32-inch)	40	12.4	8.6	4.0 - 44.0
Crook (1/32-inch)	40	13.8	9.8	3.0 - 43.0
Tiwst (1/32-inch)	40	6.0	4.9	0.0 - 20.0
Cup (1/32-inch)	40	5.3	1.3	3.0 - 9.0
Surface checks	40	0.7	1.2	0.0 - 5.0
End checks	40	0.4	0.8	0.0 - 3.0
End splits	40	0.5	0.8	0.0 - 2.0

Table 13.—Effect of position in kiln, pith location, and knots on moisture contents and drying defects of Charge 2

Dependent variables	Independent variables			
	Row	Column	Pith location	No. of knots
Green MC	NS	NS	NS	NS
Dried MC	NS	NS	NS	NS
Bow	NS	NS	NS	NS
Crook	NS	NS	NS	NS
Twist	NS	NS	NS	*
Cup	NS	NS	NS	NS
Surface checks	NS	*	**	NS
End checks	NS	NS	*	NS
End splits	NS	NS	NS	NS

boards in column one were the first to receive heated air. They were therefore subject to somewhat more severe drying conditions than columns two, three, and four which received air that had been slightly cooled and humidified by previous columns.

Drying Charge 3 (6/4 Red Oak)

Installation of a solar insolation integrator allowed measurement of the solar energy input onto the kiln. Mean daily solar radiation of 1,828.4 Btu/ft^2 (494.9 Langleys) was slightly higher than average insolation in New Orleans but slightly less than average in Lake Charles or Shreveport for the period (Table 1). Solar kiln and ambient temperature and humidity parameters are summaried in Table 14. The drying conditions reflect the harshness of Louisiana summers. Average temperature in the kiln was over 114°F, which is a good deal above average ambient (79.4°F) and was highest of all drying loads, whereas the average relative humidity (41.3 percent) was the lowest. Such conditions resulted in rather drastic drying and the load attained the lowest moisture equilibrium in the study—7.1 percent.

Figure 10 shows an upward trend in temperature and a downward trend in relative humidity as drying progresses. It also demonstrates the effects of 2 days (i.e. June 3 and 6) with little solar insolation. Neither kiln nor external ambient temperature made the usual peak at mid-afternoon, but due to good insulation and high heat storage capacity of wood, the kiln maintained a rather high temperature (over 100°F) without external heat input. Increases in ambient humidity were typical during these rainy periods. Slight increases in kiln humidity indicate that the wood was still drying despite unfavorable climatic conditions.

Even though the drying conditions were harsh, the drying rate was actually slower than previous loads because red oak is a refractory wood and difficult to dry. The average green moisture content was 81.8 percent for the kiln samples and 84.8 percent for the air samples. The kiln samples consistently dried more rapidly than the air samples, especially toward the latter stages of drying. They dried to 16.8 percent MC in 29 days, but the air samples only reached 42.0 percent in that period. After 91 days, the air samples had dried to an average 21.6 percent MC (Figure 11). Even though equilibrium was not yet reached, kiln drying was terminated at 15.4 percent MC.

The quality of drying is presented in Table 15. Surface checking was more pronounced in this load, as was end checking, probably because of harsher drying conditions and inherent characteristics of the species. Bow, crook, and twist were the lowest thus far at 0.26, 0.20, and 0.13 percent of length, respectively. Cupping, however, was most severe at 2.23 percent of width. No collapse or honeycombing was noted. Casehardening was moderate.

Analysis of variance (Table 16) showed significant relationships between dried moisture content and row and column position in the kiln, pith location, and number of knots. The row and column classes probably

Table 14.—Climatic properties inside and outside of solar kiln during Charge 3

Property	N	Mean	Standard deviation	Range
Dry bulb kiln temp (^{o}F)	696	114.2	8.1	86.0 - 132.0
Wet bulb kiln temp (^{o}F)	696	89.9	3.3	81.0 - 99.0
Humidity inside kiln (%)	696	41.3	13.3	21.0 - 85.0
Equilibrium MC of wood (%)	696	7.1	2.4	3.8 - 17.2
Ambient temp (^{o}F), campus	696	79.4	7.3	67.0 - 99.0
Ambient temp (^{o}F), airport	235	79.1	6.9	61.0 - 94.0
Ambient humidity (%), airport	235	77.3	15.7	43.0 - 100.0
Temp difference (kiln-ambient, ^{o}F)	696	34.8	9.3	2.0 - 54.0
Blackbody temp (^{o}F)	696	97.9	19.6	74.0 - 146.0
Cloud cover (1/10's)	235	5.1	3.6	0.0 - 10.0
Wind speed (mph)	235	5.6	3.1	0.0 - 18.4
Daily insolation (Btu/ft^2)	29	1,828.4	452.9	455.0 - 2,460.0

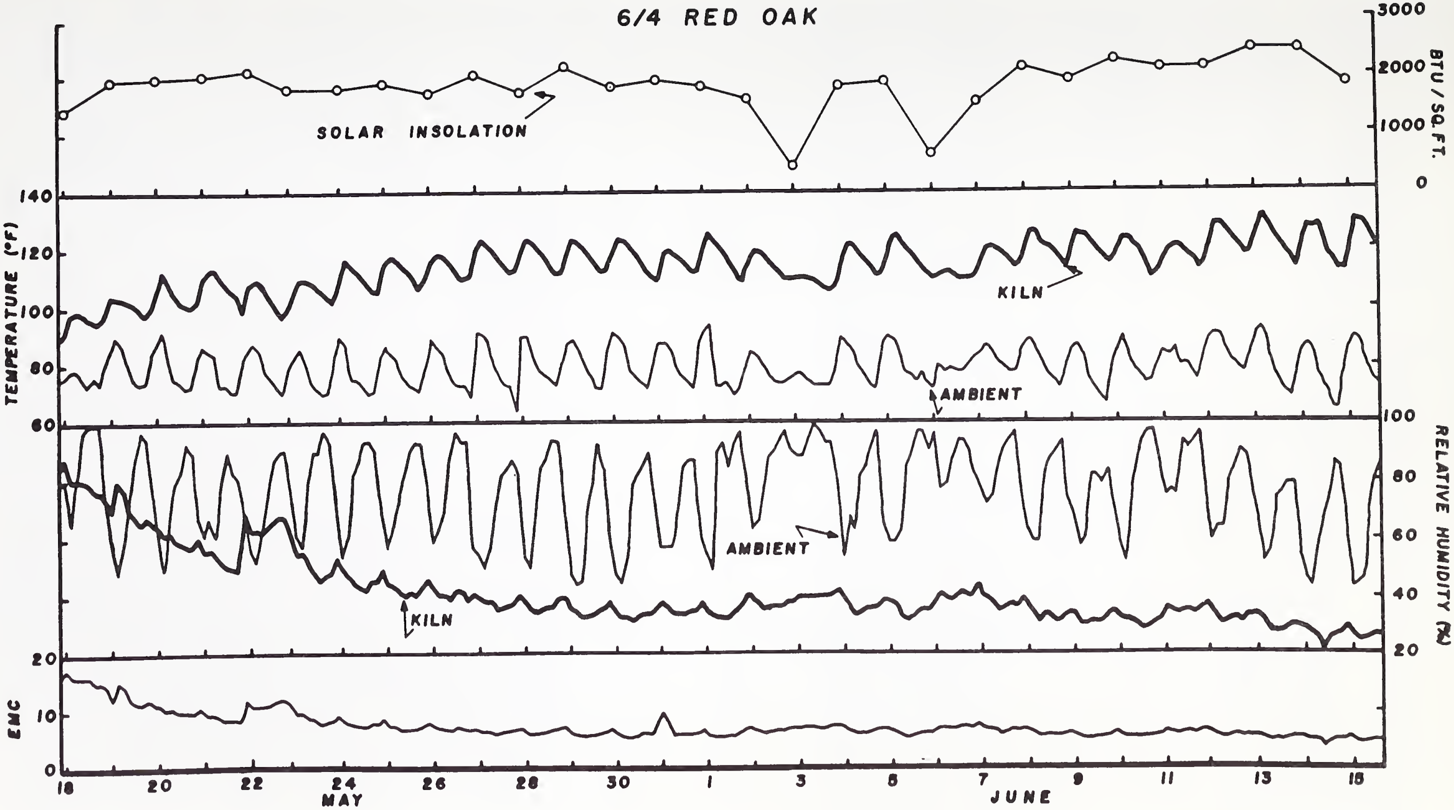

Figure 10.—Diurnal temperature, relative humidity, and EMC fluctuations during Charge 3.

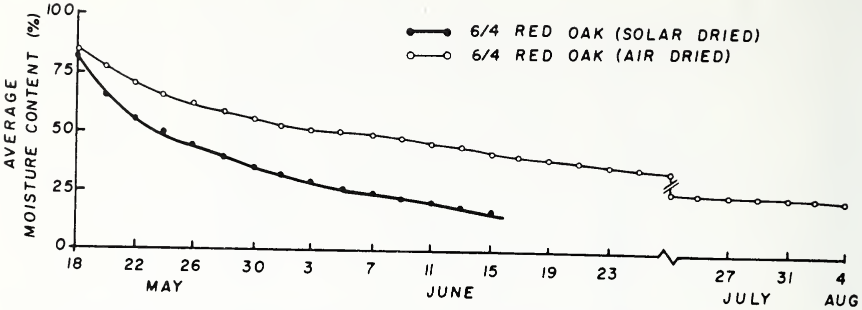

Figure 11.—Solar and air drying rates during Charge 3.

indicate inadequate air circulation. Pith location probably served as a proxy variable for heartwood/sapwood proportions. Boards with a higher percentage of sapwood seemed to have lower final moisture contents. The relationship between final moisture content and number of knots is not readily apparent but could be related to several phenomena such as sapwood/heartwood ratios and faster evaporation from end grain exposed by knots.

Table 15.—Characteristics of lumber quality in Charge 3 (6/4 No. 2 red oak)

Characteristic	N	Mean	Standard deviation	Range
Green MC (%)	40	77.0	9.4	58.8 - 93.7
Dried MC (%)	40	15.4	5.8	5.8 - 27.5
Number of knots	40	15.1	9.9	1.0 - 46.0
Bow (1/32-inch)	40	5.9	4.5	0.0 - 23.0
Crook (1/32-inch)	40	4.5	2.8	1.0 - 14.0
Twist (1/32-inch)	40	2.9	3.5	0.0 - 14.0
Cup (1/32-inch)	40	5.7	1.2	3.0 - 8.0
Surface checks	40	15.6	10.0	0.0 - 38.0
End checks	40	4.6	3.3	0.0 - 12.0
End splits	40	0.8	1.0	0.0 - 4.0

Table 16.—Effect of position in kiln, pith location, and knots on moisture contents and drying defects of Charge 3

Dependent variables	Independent variables			
	Row	Column	Pith location	No. of knots
Green MC	NS	NS	NS	NS
Dried MC	***	*	**	**
Bow	NS	NS	NS	NS
Crook	NS	NS	NS	NS
Twist	NS	NS	NS	NS
Cup	NS	NS	NS	NS
Surface checks	NS	NS	NS	NS
End checks	NS	NS	NS	NS
End splits	NS	NS	NS	NS

Drying Charge 4 (4/4 Ash)

This load of lumber was dried late in the summer when solar insolation had begun to taper off. An average of 1,645.1 Btu/day of heat energy was available to each square foot of solar collector. Once again, this value appears to be intermediate between the averages for New Orleans on the low side, and Lake Charles and Shreveport on the high side. The kiln maintained an average temperature of 110.7°F, which is slightly below the 114.2°F average set earlier in the summer (Table 17). The average temperature difference between kiln and ambient was 24.8°F. The average relative humidity in the kiln (54.5 percent) was considerably lower than that of the ambient environment (78.7 percent). Diurnal temperature and humidity fluctuations are shown in Figure 12.

The trend of rising temperature and falling humidity during drying occurred with the thinner lumber material as it did in previous loads. Equilibrium moisture content seemed to follow a pattern similar to relative humidity but was subject to slightly less variation. Diurnal temperature fluctuations were slightly higher, probably due to less lumber volume.

The average green moisture content was 49.9 percent for the kiln samples and 47.8 percent for the air samples. The kiln samples dried from the green condition to 6.7 percent MC in 20 days; whereas the matched air samples were able to reach 21.0 percent MC in that period and 16.4 percent

Table 17.—Climatic properties inside and outside of solar kiln during Charge 4

Property	N	Mean	Standard deviation	Range
Dry bulb kiln temp (^{o}F)	480	110.7	10.3	88.0 - 136.0
Wet bulb kiln temp (^{o}F)	480	92.9	4.9	82.0 - 106.0
Humidity inside kiln (%)	480	54.5	18.2	29.0 - 93.0
Equilibrium MC of wood (%)	480	9.6	4.2	4.9 - 21.2
Ambient temp (^{o}F), campus	480	85.9	7.7	71.0 - 98.0
Ambient temp (^{o}F), airport	158	80.3	6.5	69.0 - 96.0
Ambient humidity (%), airport	158	78.7	14.3	42.0 - 97.0
Temp difference (kiln-ambient, ^{o}F)	480	24.8	10.9	-5.0 - 49.0
Blackbody temp (^{o}F)	480	102.1	17.4	74.0 - 145.0
Cloud cover (1/10's)	158	5.0	3.6	0.0 - 10.0
Wind speed (mph)	158	5.3	3.3	0.0 - 17.2
Daily insolation (Btu/ft^2)	20	1,645.1	373.9	989.0 - 2,124.0

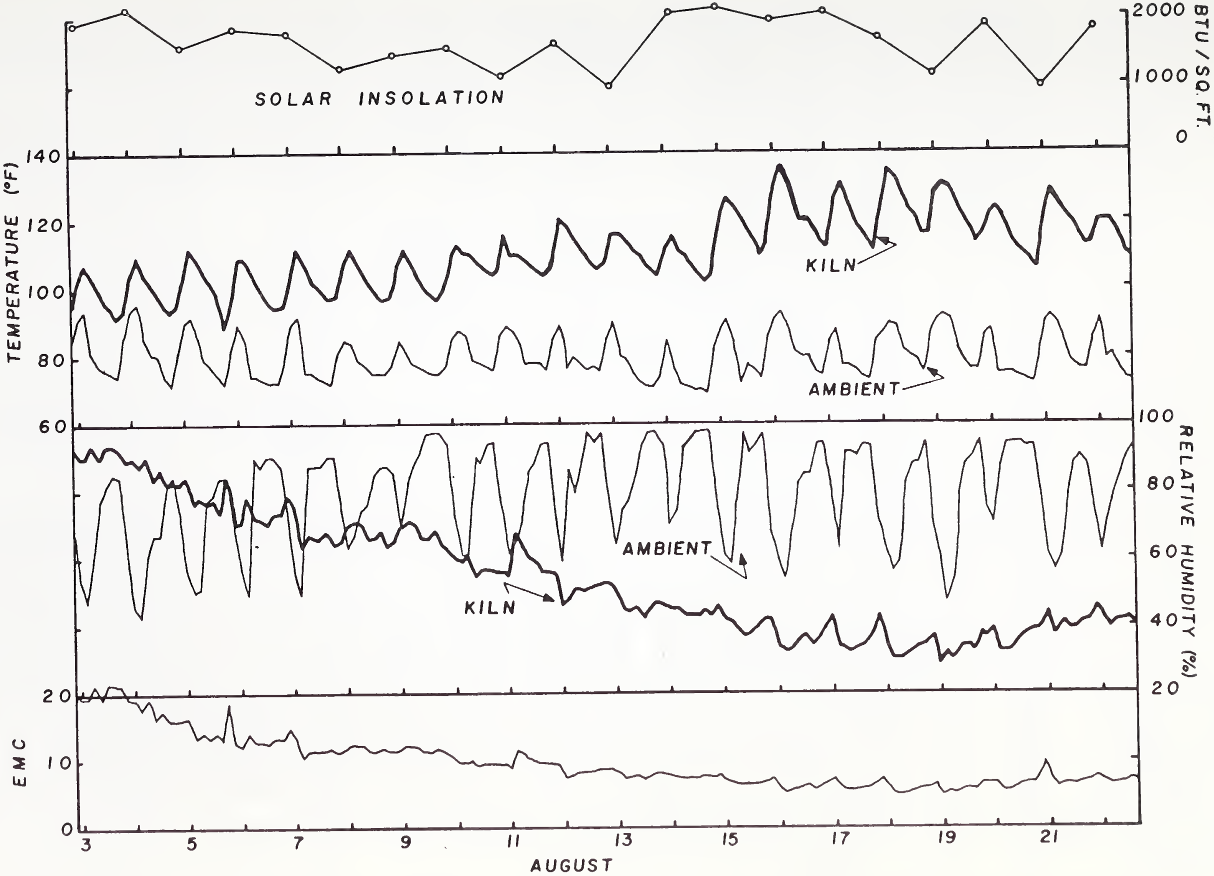

Figure 12.—Diurnal temperature, relative humidity, insolation and EMC fluctuations during Charge 4.

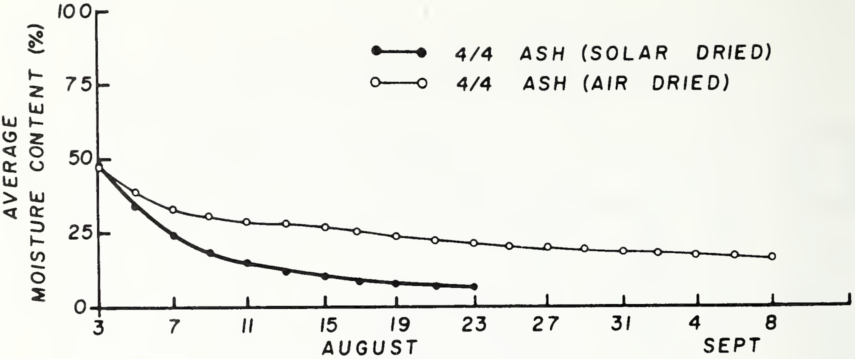

Figure 13.—Solar and air drying rates during Charge 4.

MC in 36 days (Figure 13). The final average moisture content for the kiln samples was 6.7 percent, and that of the charge was 6.8 percent. The coefficient of variation for the dried moisture content was 8.2, compared with 19.1 for the green moisture content, thus uniform drying was easily obtained with the thinner boards. The final moisture content was once again significantly affected by row position in the lumber pile. Drying rate was considerably faster for solar-dried boards than for the air-dried boards.

There was very little drying degrade in this load despite the poor quality (No. 3 Common) of the lumber material (Table 18). Analysis of variance showed that checking and splitting were highly significantly related to pith

Table 18.—Characteristics of lumber quality in Charge 4 (4/4 No. 3 ash)

Characteristic	N	Mean	Standard deviation	Range
Green MC (%)	71	50.5	9.6	21.3 - 80.7
Dried MC (%)	71	6.8	0.6	5.7 - 8.5
Number of knots	71	3.4	3.6	0.0 - 21.0
Bow (1/32-inch)	71	5.6	2.7	0.0 - 13.0
Crook (1/32-inch)	71	6.6	4.1	0.0 - 24.0
Twist (1/32-inch)	71	5.5	3.6	0.0 - 20.0
Cup (1/32-inch)	71	1.7	1.4	0.0 - 6.0
Surface checks	71	0.2	0.8	0.0 - 4.0
End checks	71	0.0	0.0	0.0 - 0.0
End splits	71	0.2	0.6	0.0 - 3.0

location (Table 19). The analysis also showed that final moisture content was highly significantly related to the row position in the lumber pile. Bow, crook, and twist were 0.24, 0.29, and 0.24 percent of length, respectively. Cup was only 0.66 percent of width. The low cup is probably due to thinner boards and excellent dimensional stability of ash. Surface checking and end-splitting were very low, and end-checking was non-existent. No collapse or honeycombing was found, and only slight casehardening developed.

Table 19.—Effect of position in kiln, pith location, and knots on moisture contents and drying defects of Charge 4

Dependent variables	Independent variables			
	Row	Column	Pith location	No. of knots
Green MC	NS	NS	NS	NS
Dried MC	**	NS	NS	NS
Bow	NS	NS	NS	NS
Crook	NS	NS	NS	NS
Twist	NS	NS	NS	NS
Cup	NS	NS	NS	NS
Surface checks	NS	NS	***	NS
End checks	--[1]	--	--	--
End splits	NS	NS	***	NS

[1] No end checks were observed.

Drying Charge 5 (4/4 Cypress)

Early fall is typically the sunniest season in Louisiana, and October was no exception. The average cloud cover of 24 percent was the lowest for all drying charges. Daily solar radiation averaged 1,482.5 Btu/ft^2 over the 21-day drying period. This is approximately equivalent to the average October solar insolation in Lake Charles but is higher than that of Shreveport or New Orleans. As shown in Table 20, the mean kiln temperature was 96.4°F, which was 28.8°F above average ambient (67.6°F). The

Table 20.—Climatic properties inside and outside of solar kiln during Charge 5

Property	N	Mean	Standard deviation	Range
Dry bulb kiln temp (^{O}F)	504	96.4	11.5	71.0 - 121.0
Wet bulb kiln temp (^{O}F)	504	81.0	6.5	66.0 - 98.0
Humidity inside kiln (%)	504	55.5	20.3	14.0 - 96.0
Equilibrium MC of wood (%)	504	10.4	4.8	2.7 - 24.0
Ambient temp (^{O}F), campus	504	67.6	7.7	50.0 - 87.0
Ambient temp (^{O}F), airport	170	64.9	10.3	42.0 - 86.0
Ambient humidity (%), airport	170	70.5	21.9	28.0 - 100.0
Temp difference (kiln-ambient, ^{O}F)	504	28.8	9.5	2.0 - 47.0
Blackbody temp (^{O}F)	504	84.6	21.9	51.0 - 132.0
Cloud cover (1/10's)	170	2.4	3.4	0.0 - 10.0
Wind speed (mph)	170	5.4	4.1	0.0 - 19.6
Daily insolation (Btu/ft^2)	21	1,482.5	197.9	955.0 - 1,734.0

mean relative humidity in the kiln was 55.5 percent, while mean ambient was 70.5 percent.

Figure 14 illustrates the generally high level of solar insolation throughout the drying period. The previously recognized upward trend in kiln temperature and downward trend in kiln humidity is apparent. The graph also shows the extent of ambient humidity fluctuations even during a period of consistently clear and sunny weather. Contrast these with the comparatively small diurnal humidity fluctuations in the kiln. Equilibrium moisture content seemed to again follow kiln humidity rather closely.

The inclusion of southern pine samples in the charge allowed several interesting observations. The drying rate of the very permeable pine is exceptionally fast, even when compared to the relatively fast-drying cypress (Figure 15). The average green moisture content of the four cypress kiln samples was 88.4 percent while the air samples averaged 88.9 percent. The lumber dried very rapidly to 9.6 percent MC in 21 days in the solar kiln, whereas the matching air samples reached only 25.1 percent MC in that same time period and required 54 days to reach 18.9 percent MC. The southern pine kiln samples started from 160.4 percent MC and dried to 9.6 percent MC in 10 days and to 6.6 percent MC in 21 days. The pine air samples reached 48.6 percent MC in 10 days, 21.9 percent in 21 days, and 20.6 percent in 34 days.

The pine samples also demonstrate the difference in drying rate above and below the fiber saturation point, and indicate the need for more severe drying conditions during the latter stages. Since the pine samples made up a very small percentage of the total lumber volume, drying conditions were determined by the temperature/moisture interrelationships of the cypress. In previous loads, relative humidity in the kiln was reported to be directly related to wood moisture and inversely related to temperature. Assuming similar conditions existed in the cypress load, the pine had a comparative advantage in the initial drying stages. Because the humidity of the kiln was determined by the cypress at a lower moisture content, the pine initially had relatively more potential for evaporation. Once in the hygroscopic range though, the pine dried by a diffusion process, and the removal of moisture was slowed considerably by the mild drying conditions (i.e. lower temperature) caused by the wetter cypress lumber.

The quality of the seasoned lumber, shown in Table 21, was very good. Analysis of variance showed no significant effects of position in the kiln, pith location, or number of knots on the green moisture content, dried moisture content, or drying defects. No collapse or honeycombing was found, and only slight casehardening developed.

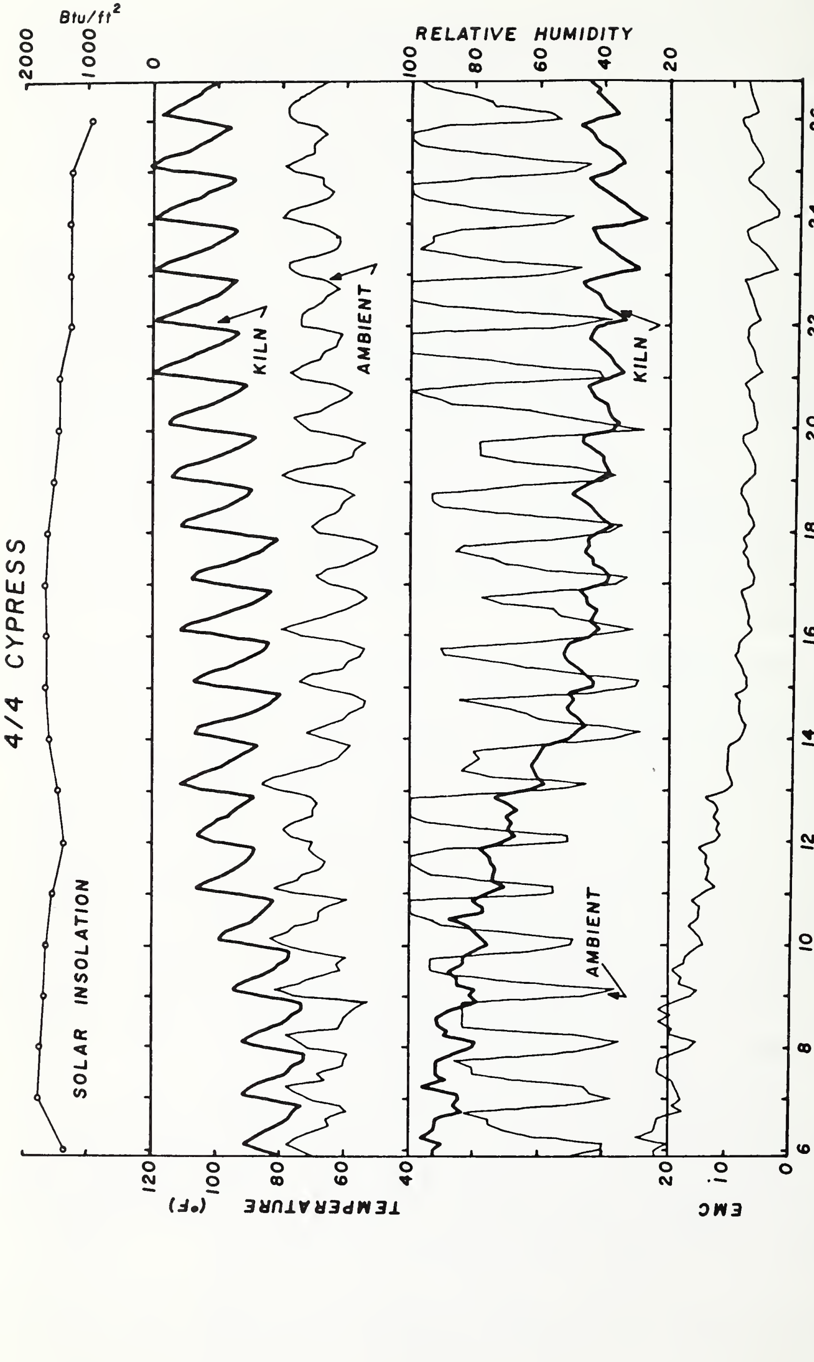

Figure 14.—Diurnal temperature, relative humidity, insolation, and EMC fluctuations during Charge 5.

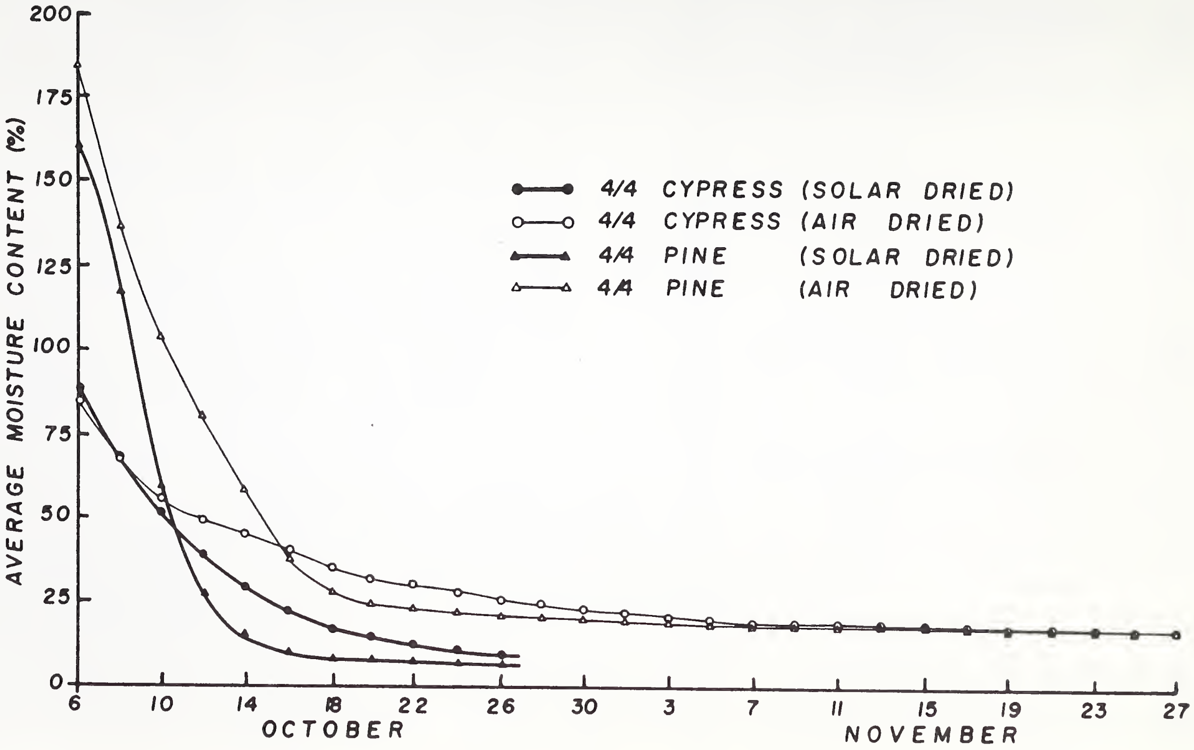

Figure 15.—Solar and air drying rates during Charge 5.

Table 21.—Characteristics of lumber quality in Charge 5 (4/4 No. 2 cypress)

Characteristic	N	Mean	Standard deviation	Range
Green MC (%)	56	101.2	25.8	51.5 - 147.4
Dried MC (%)	56	7.2	2.3	5.8 - 14.5
Number of knots	56	3.8	3.2	0.0 - 10.0
Bow (1/32-inch)	56	4.5	3.6	0.0 - 16.0
Crook (1/32-inch)	56	5.5	6.6	0.0 - 32.0
Twist (1/32-inch)	56	6.6	5.8	0.0 - 24.0
Cup (1/32-inch)	56	2.2	1.6	0.0 - 8.0
Surface checks	56	1.5	3.9	0.0 - 20.0
End checks	56	0.0	0.2	0.0 - 1.0
End splits	56	0.2	0.4	0.0 - 1.0

Drying Charge 6 (6/4 Red Oak)

The most severe test on the solar kiln was undertaken in the drying of a refractory red oak in the middle of the winter. The weather was cold, rainy and cloudy for the most part, with daily insolation averaging only 754.8 Btu/ft^2. This value is below the average for the period for Shreveport, Lake Charles, and New Orleans. The temperature of the kiln nudged above 100°F only 4 days and averaged only 82.2°F. It still averaged 28.4°F above ambient (Table 22). The temperature of the kiln (CV = 11.4) was more stable than the external ambient (CV = 25.8). The low temperatures during this period led to relatively high kiln humidities (average 63.0 percent) and equilibrium moisture contents (average 12.3 percent).

Figures 16a and 16b illustrate the relationships between solar insolation, ambient temperature and humidity, and drying conditions. Although the kiln was well insulated, its temperature seemed to follow the ambient temperature rather closely. This was partially due to air infusion during weight measurements, to leaks around the door during other periods, and to thermal leaks in places where insulation was as thick as desirable (i.e. near vents to the solar collector, at plumbing and electrical connections, etc). Kiln and ambient humidity do not seem to be directly related to each other, but may be indirectly related through the general level of solar radiation. Cloudy days typically had high humidities, usually caused by rain. The relative humidity in the kiln tended upward in these periods due to continued evaporation (i.e. increasing absolute humidity while simultaneously

Table 22.—Climatic properties inside and outside of solar kiln during Charge 6

Property	N	Mean	Standard deviation	Range
Dry bulb kiln temp (^{O}F)	1464	82.2	9.3	51.0 - 103.0
Wet bulb kiln temp (^{O}F)	1464	72.2	10.6	45.0 - 96.0
Humidity inside kiln (%)	1464	63.0	16.9	32.0 - 100.0
Equilibrium MC of wood (%)	1464	12.3	5.1	6.0 - 28.3
Ambient temp (^{O}F), campus	1464	53.8	13.9	22.0 - 79.0
Ambient temp (^{O}F), airport	157	63.2	8.8	46.0 - 80.0
Ambient humidity (%), airport	157	61.4	33.9	31.0 - 100.0
Temp difference (kiln-ambient, ^{O}F)	1464	28.5	8.8	7.0 - 54.0
Blackbody temp (^{O}F)	1464	60.1	28.3	24.0 - 116.0
Cloud cover (1/10's)	157	6.9	3.5	0.0 - 10.0
Wind speed (mph)	157	5.3	3.0	0.0 - 11.5
Daily insolation (Btu/ft^2)	61	754.8	344.1	133.0 - 1,210.0

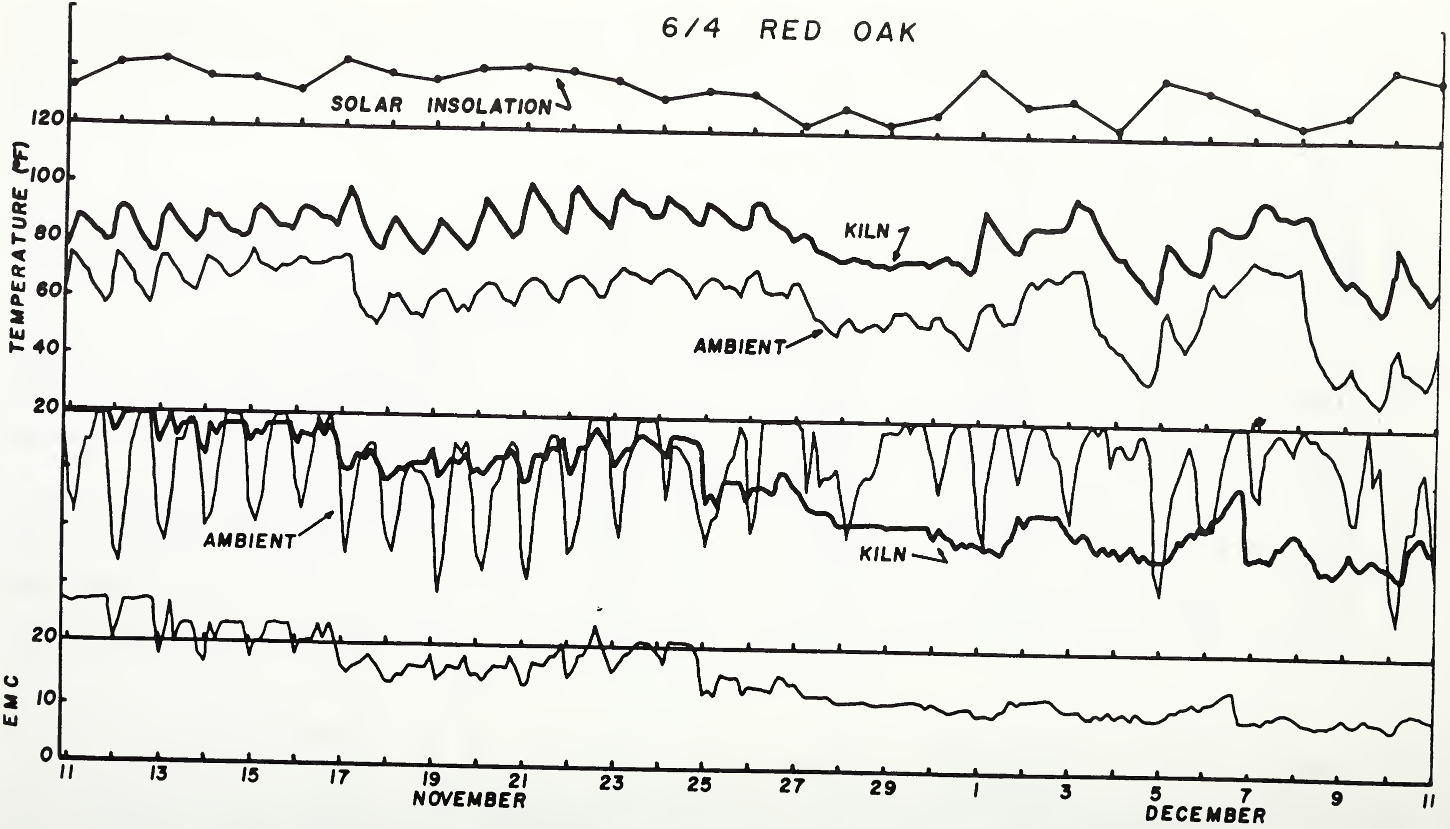

Figure 16a.—Diurnal temperature, relative humidity, and EMC fluctuations during Charge 6.

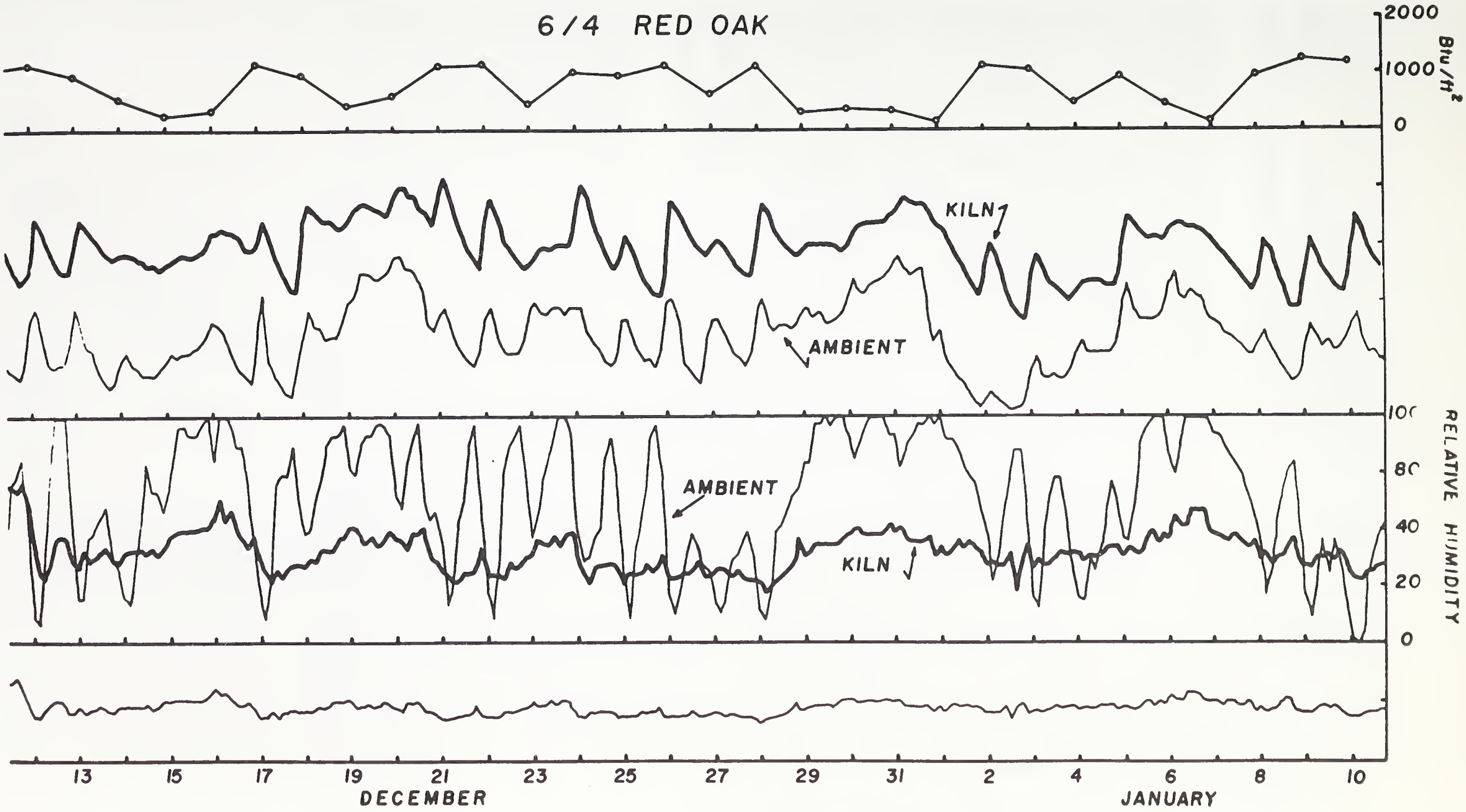

Figure 16b.—Diurnal temperature, relative humidity, and EMC fluctuations during Charge 6.

lowering temperatures) with little heat input. The equilibrium moisture content seems to follow kiln humidity closely. The typical upward trend in temperature is noticeable during some periods (November 11-26 and December 10-21) but an overall trend is masked by variability in solar insolation and ambient temperature.

Solar- and air-drying rates for the 6/4 red oak and the 8/4 southern pine are graphically depicted in Figure 17. The red oak dried considerably slower, with the kiln samples drying from 92.4 percent MC to 17.3 percent in 62 days and the air-dried samples reaching 29.8 percent MC in 112 days. After 62 days, the red oak had air-dried to only 37.5 percent MC. The southern pine kiln samples started from 111.0 percent MC and dried to 17.0 percent in approximately 13 days and to 9.0 percent in 62 days. The air-dried pine samples reached 37.0 percent MC in 21 days and 17.6 percent in 62 days. Even though the pine boards were thicker than the oak, the former dried faster and reached lower final moisture content.

The mild drying conditions had some favorable effects. As shown in Table 23, checking was considerably reduced from the level found in the red oak previously dried in the summer (which was also 6/4 thick). Casehardening was also less severe. The surface checking that was observed was significantly related to row position in the kiln and pith location. The relation to pith location probably stems from the weaker, dimensionally less stable wood near the pith. The relationship to row position probably indicates uneven air circulation in the kiln.

Bow, crook, and twist were 0.2, 0.4, and 0.6 percent of length, respectively, and cup was 1.7 percent of width. Analysis of variance showed that the row position in the lumber pile was a significant source of crook, twist, and surface checks (Table 24), indicating the need to restrain warping in small piles, possibly by using weights on top of the wood stack. No collapse or honeycombing was found, and only slight casehardening developed. Blue stain fungus developed on the pine air samples, but not on the oak samples because they had been treated with preservatives at the mill. The solar-dried pine samples dried fast enough in the kiln so that no blue stain developed even without preservative treatment.

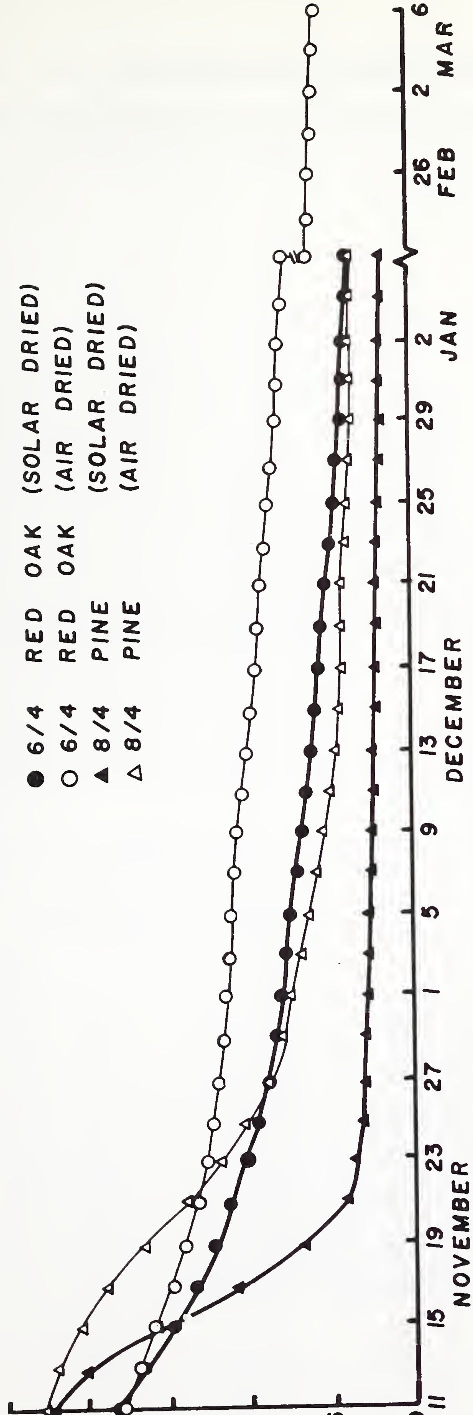

Figure 17.—Solar and air drying rates during Charge 6.

Table 23.—Characteristics of lumber quality in Charge 6 (6/4 No. 2 red oak)

Characteristic	N	Mean	Standard deviation	Range
Green MC (%)	41	90.1	7.4	78.0 - 107.1
Dried MC (%)	41	14.1	4.4	7.7 - 21.8
Number of knots	41	3.0	2.3	0.0 - 10.0
Bow (1/32-inch)	41	4.4	4.0	0.0 - 16.0
Crook (1/32-inch)	41	9.0	6.5	0.0 - 30.0
Twist (1/32-inch)	41	14.2	7.6	2.0 - 36.0
Cup (1/32-inch)	41	4.3	3.0	0.0 - 10.0
Surface checks	41	4.3	9.4	0.0 - 46.0
End checks	41	0.7	1.4	0.0 - 5.0
End splits	41	0.5	1.0	0.0 - 4.0

Table 24.—Effect of position in kiln, pith location, and knots on moisture contents and drying defects of Charge 6

Dependent variables	Independent variables			
	Row	Column	Pith location	No. of knots
Green MC	NS	NS	NS	NS
Dried MC	NS	NS	NS	NS
Bow	NS	NS	NS	NS
Crook	*	NS	NS	NS
Twist	*	NS	NS	NS
Cup	NS	NS	NS	NS
Surface checks	**	NS	**	NS
End checks	NS	NS	NS	NS
End splits	NS	NS	NS	NS

Discussion and Summary

To measure the effectiveness of a solar kiln one must not only measure output (i.e. heat rise above ambient) but input, the latter being defined as the amount of heat collected in the solar collectors. Heat collection is determined by solar radiation, collector area, and collector efficiency. Since solar radiation is uncontrollable, collector size and efficiency are the primary design variables. To compare kilns of different sizes, the ratio of solar collector area to lumber volume may be substituted for total collector area. The solar collector area is defined as the area of transparent glazing through which solar radiation passes. The average volume of lumber dried in the six loads was 297 bd-ft, making the average collector to lumber volume ratio 0.088 ft^2/bd-ft. This value is far below the ratios of other kilns reported in the literature which range from 0.209 ft^2/bd-ft (Chudnoff et al. 1966) to 0.744 ft^2/bd-ft (Peck 1962). Plumptre (1967) built three solar kilns with ratios of about 0.167 ft^2/bd-ft, but these included external reflectors and do not fit well into the collector/lumber volume ratio model.

The air-dried boards took an average of 2.5 times longer to reach 30 percent MC and 3.5 times longer to 20 percent MC than the solar kiln-dried boards (Table 5), even though the drying rate in some species was slower in the solar kiln during the initial drying period. Solar drying also enabled the boards to reach a lower final moisture content. Results from other studies indicate similar trends. Plumptre (1967) found approximately equivalent drying rates between solar and air drying to 30 percent MC, but overall air drying took 2.5 to 3 times longer to dry. Peck (1962) and Maldonado and Peck (1962) reported that drying to 20 percent MC was approximately twice as fast for solar drying as air drying. Chen and Rosen (1979) indicated that yellow poplar lumber dried in less time by solar kiln drying than by air drying, but the rate of drying in the kiln was initially quite slow, and air drying to about 45 percent MC was actually faster than solar drying. It was during the later stage of the drying period when solar drying became effective, due to lower relative humidity and higher temperature.

Overall, drying degrade in this study was very low, especially since the lumber was of low quality (No. 2 and No. 3 Common). Average bow, crook, and twist were 0.28, 0.32, and 0.29 percent of length respectively. Cup was 1.29 percent of width. The average number of surface checks per board was 3.1, but most were present in oak. The average number of surface checks per board in species other than oak was 0.6, while in oak the average was 9.9. End checking and end-splitting were very low, averaging less than one per board.

Analysis of variance indicated that species was a highly significant ($P<0.001$) source of variability for green and dried moisture content, warping defects, and surface and end checking. It was not a significant source of end splitting, however, because this was highly significantly related to pith location. Some of the species effect might be attributed to a drying charge class since each charge was dried under different conditions and thickness of the loads varied.

Pith location was the second most important independent variable class. Its effect on green moisture content and dried moisture content is highly significant, due to differences in heartwood/sapwood proportion. The weak, dimensionally unstable juvenile wood generally associated with pith is very subject to cupping, checking, and splitting; therefore, highly significant interrelationships between pith and warping defect are expected. The significant relationship of twist to pith location was probably because the pith in cut lumber rarely ran parallel to the edges. Thus, cupping was uneven along the length, and this led to a certain amount of twisting.

The number of knots in each board was included to serve as an indicator of lumber quality. The relationship between knots and dried moisture content was highly significant, probably because of faster evaporation from exposed grain in boards containing knots. Cupping, twisting, and surface checking may be caused by drying stresses and uneven grain around knots.

Dried moisture content was highly significantly affected by row position of the board, indicating variable air circulation throughout the drying pile. Efforts to minimize this effect by altering stickering spacing, baffling, etc., were unsuccessful because of vent size and fan location. Such problems would not have occurred if the solar kiln had not been retrofitted from an existing structure.

Conclusions

From this study the following conclusions can be drawn:

1. Solar drying can be 2.5 to 3.5 times faster than conventional air drying in Louisiana, depending on the degree of drying required, species, and lumber dimension.
2. Solar drying can be used to dry wood to the 7 to 8 percent moisture content required for indoor use, particularly if thinner boards of non-refractory and easy-to-dry species are used.
3. Solar drying can be used to predry refractory hardwoods at a faster rate than air drying. When the wood is then finished in a conventional kiln, fuel is saved and inventory turnover is faster than in an air drying to conventional kiln drying scheme.
4. Quality of solar dried lumber is good, and drying regrade can be held to acceptable limits.

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